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VOL. 19, NO. 1 March, 1944

THE QUARTERLY REVIEW
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WALLACE'S LINE IN THE LIGHT OF RECENT ZOOGEOGRAPHIC STUDIES

By ERNST MAYR
American Museum of Natural History, New York

ZOOGEOGRAPHY has had a fate very much like taxonomy. It was flourishing during the descriptive period of biological sciences. Its prestige, however, declined rapidly when experimental biology began to come to the foreground. Again as with taxonomy, a new interest in zoogeography has been noticeable in recent years. It seems to me that this revival has had two causes. One is the interest of the student of geographic speciation in the findings of the zoogeographer. A study of past and present distributions yields much information on isolation of populations and on the dispersal of species. It is in this connection that I became interested in zoogeography.

The other reason is the introduction of new methods. The intensive exploration of all corners of the globe during the past fifty years has led to an accumulation of sufficient faunistic data to permit the application of statistical methods. Furthermore, the science of ecology has reached a level of maturity at which it is beginning to affect profoundly zoogeographic methods and principles. It seemed worth while to me to study the controversial and still wide open subject of the borderline between the Australian and Oriental Regions with the help of such modern methods.

A. R. Wallace, who is generally considered the foremost representative of classical zoogeography, states in his famous essay *On the zoological geography of the Malay Archipelago* (1860): "The western and eastern islands of the archipelago belong to regions more distinct and contrasted than any other of the great zoological divisions of the globe. South America and Africa, separated by the Atlantic, do not differ so widely as Asia and Australia." There is much truth in this statement. Except for bats and a few rodents, the only native mammals of Australia are marsupials and monotremes. These same two groups are entirely lacking in Asia and are replaced by a wide variety of placental mammals, such as monkeys, shrews, squirrels, ungulates, and so forth. An equally pronounced faunal difference exists among birds, insects, and other groups of animals of the two regions.

Australia and Asia are connected by a belt of islands, the Malay Archipelago, and the question naturally comes up as to where in this island region the borderline is to be drawn between these two fundamentally different faunas. After reviewing the zoological evidence known to him, Wallace (*l.c.*) comes to the following conclusion: "We may consider it established that the Strait of Lombok [between Bali and Lombok] (only 15 miles wide) marks the limit and abruptly separates two of the great zoological regions of the globe." With these words he drew a zoogeographic boundary which was destined to gain fame under the name of its author: "Wallace's Line," a term first used by Huxley (1868) (Fig. 1). It runs between Bali and Lombok in the south, then through Makassar Strait between Borneo and Celebes, and finally turns into the open Pacific between Mindanao (Philippines) and the Sanghir Islands. This convenient borderline found quick acceptance in the zoological literature and was without hesitation adopted by nearly all the zoogeographers publishing between 1860 and 1890. Sarasin (1901) and Pelseneer (1904) should be

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consulted for a historical survey of the earlier literature. The echo in the popular literature of this period was even more enthusiastic. A mysterious line, only 15 miles wide, that separates marsupials from tigers, and honey eaters and cockatoes from barbets and trogons, could not fail to appeal to the imagination of the layman.

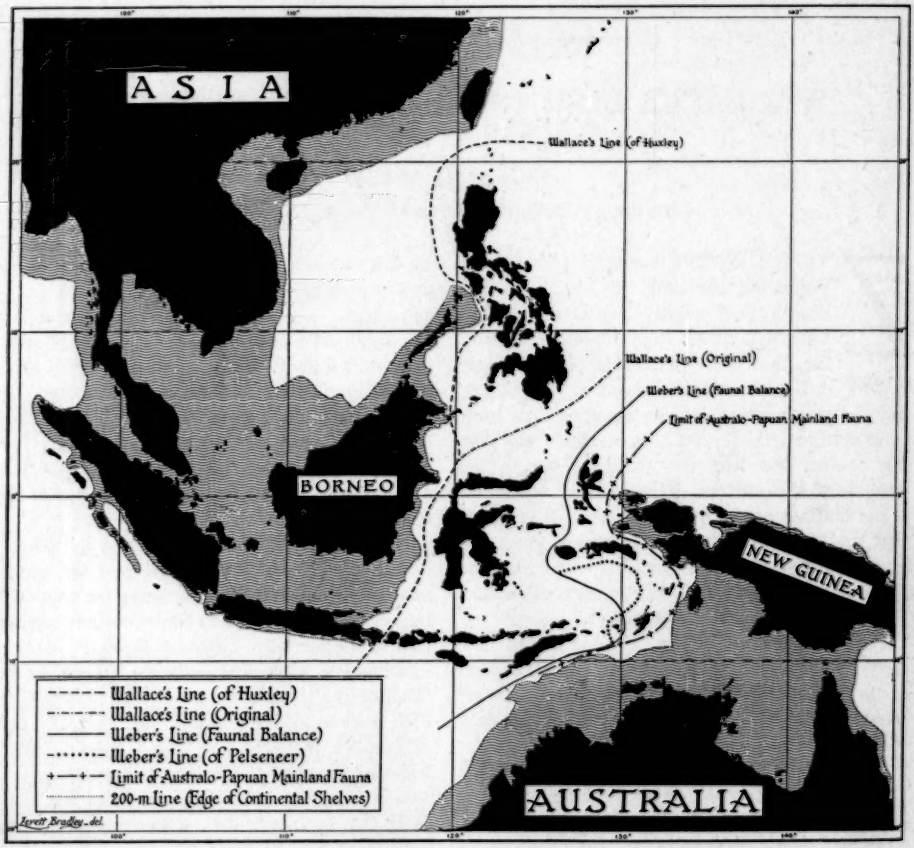

FIG. 1. ZOOGEOGRAPHIC BORDERLINES IN THE MALAY ARCHIPELAGO
The shaded areas are the continental shelves.

E. Haeckel (1893) outdid all his contemporaries by asserting: "Crossing the narrow but deep Lombok Strait we go with a single step from the Present Era to the Mesozoicum."

Statements of such exaggeration call for refutation and shortly after 1890 doubts were expressed more and more frequently as to the validity of Wallace's Line, particularly after the distributional facts became better known. Wallace himself was much less positive in his later writings. Since then many writers have insisted that Wallace's Line was entirely imaginary (Weber (1902), Pelseneer (1904), Mertens (1930), Brongersma (1936), and others). Van Kampen (1909), for example, asserted: "Such a sharp boundary as Wallace drew it does not exist. Not only is there none where he drew it, but no such line exists anywhere in the archipelago." On the other hand, Wallace's Line has been vigorously defended by such serious authors as Dickerson *et al.* (1928), Raven (1935), and Rensch (1936). Curiously enough most of the writers on this subject seem to be definitely in one or the other camp, either

they are for Wallace's Line or they are against it, and they tend to present their data accordingly. Others treat one aspect only of this diversified problem. An impartial study of the situation is still lacking at the present time.

Actually, a whole complex of questions is involved, of which the following seem to be the most important ones:

(1) Is Wallace's Line the borderline between the Oriental and the Australian Regions, and if not, where is this borderline?

(2) Does Wallace's Line represent the line of a major faunal break, and if this is true, how did such a break develop?

IS WALLACE'S LINE THE BOUNDARY BETWEEN THE ORIENTAL AND THE AUSTRALIAN REGIONS?

The fauna of the Malay Archipelago was rather poorly known in Wallace's days. Where he knew 20 species of birds, we now know 120; where he knew 5 species of reptiles, we know 40, and so forth. This lack of information caused Wallace to single out what he considered typical representatives of the respective faunas, and to use the borderline of their ranges as zoogeographic boundaries. The tiger, the squirrels and other mammals go as far east as Bali, but are absent from Lombok. Among birds the barbets (Capitonidae) and many other Oriental groups are abruptly brought to a halt by Lombok Strait. The Australian honeyeaters (genera *Philemon* and *Meliphaga*) and the cockatoe (*Cacatua*) reach Lombok, but not Bali. The faunal difference on either side of Makassar Strait is even more striking: A rich Oriental fauna on Borneo and a marsupial (*Phalanger*) on Celebes. It was on the basis of such data that Wallace came to the conclusion that Lombok and Makassar Straits form the boundary between the Oriental and the Australian Regions.

An analysis of the now available extensive faunal lists does not bear out Wallace's conclusion. After eliminating a few widespread species, the fauna of each of the islands of the Malay Archipelago can be divided readily into two groups: One consists of western species, that is, species which are derived from the Oriental Fauna, the other of eastern species, that is, such which are derived from the Australian Fauna. In a few species it is apparent that the genus or the family to which they belong was originally of western origin, but that the particular species arrived in the island belt from the east as a descendant of a group of species that was isolated in Australia at an early date. Such secondarily eastern elements, as *Merops ornatus* among the birds, are included with the eastern group. The classification of a few species will always remain open to doubt, but a different decision in these cases would change the percentages only slightly and would not basically affect the following figures. A specialist of a given group usually has no difficulties in deciding which species are Indo-Malayan and which Australian.

Celebes. Weber (1902), the Sarasins (1901), de Beaufort (1926), Stresemann (1939) and other recent authors agree that at least three fourths of the Celebes animals are of western origin. According to Rensch (1936: 252) the figures are: Reptiles at least 88 per cent, Amphibia 80 per cent and butterflies 86 per cent. In birds the figure is slightly lower. Among 74 species of Passerine birds 67.6 per cent are western. The percentage for the old endemics (genera and good species) and for the more recent immigrants is quite similar. There is no doubt, Celebes must be included with the Oriental Region.

TABLE 1

Percentage of western and eastern species on Lesser Sunda Islands

	REPTILES AND AMPHIBIANS	BIRDS		CHANGE OF PERCENTAGE IN BIRDS
	Western	Western	Eastern	
	Per cent	*Per cent*	*Per cent*	
Bali	94	87.0	13.0	14.5
Lombok	85	72.5	27.5	4.5
Sumbawa	87	68.0	32.0	5.0
Flores	78	63.0	37.0	5.5
Alor Group	—	57.5	42.5	

Lesser Sunda Islands. Table 1 shows the ratio of the western and the eastern elements on a number of islands (the data of reptiles and amphibians are from Mertens, 1930; the data on birds are original). Rensch's (1936) careful analysis shows that the Indo-Malayan element prevails numerically as far east as the islands of the Timor group. This is equally true for flying animals (birds and butterflies) and for flightless groups (mammals, land snails).

The figures in Table 1 permit only a single conclusion: Wallace's Line is not the borderline

between the Australian and the Oriental Regions. The first of the questions asked above is thus answered in favor of Wallace's opponents.

DOES WALLACE'S LINE INDICATE A MAJOR FAUNAL BREAK?

The fact that Wallace's Line is not the border between the Oriental and the Australo-Papuan Regions is not the complete answer to our problem. A line which has been defended so vigorously by so many zoogeographers must have some significance. It is worthy of notice that its staunchest defenders were those naturalists who actually studied and collected the animal life on both sides of the line, like Dickerson and his associates in the Philippines, like Raven who repeatedly crossed Makassar Strait in a sail boat from Borneo to Celebes and back, and like Wallace and Rensch who crossed back and forth between Bali and Lombok. The actual impressions of these workers are vividly depicted in a quotation from one of Rensch's books. Arriving on Bali after a prolonged exploration of Lombok, Sumbawa and Flores, he asks himself:

"What about the animal life? Is it really as different from that of Lombok, as has been claimed by so many other travellers? Is the small strait between the two islands actually a sharp faunal division? A strait, which even the smallest bird could cross without any difficulties? . . . And the difference is indeed quite extraordinary! Much more conspicuous than I would have ever imagined. As soon as I entered the woods on a small native trail a whole chorus of strange bird songs greets me—in fact, among the real songsters there is not a single one with which I was familiar [from the islands east of Wallace's Line]. . . . One surprise follows the other. The very species that are most common on Bali, are absent on the islands to the east. The most characteristic bird of these woods is a green barbet . . . it belongs to the family Capitonidae which is entirely absent on Lombok! The woodpeckers also, which are represented on the islands farther east by a single species only, are found on Bali in five different species. On the other hand I missed a whole number of species of birds which are characteristic for the islands visited previously . . ." (Rensch 1930).

An unemotional statistical analysis of the faunal data tends to support Rensch's assertions. The most striking feature of Wallace's Line is that it separates a zone with a rich animal life from a badly impoverished one. Borneo has about 420 species of breeding birds, Celebes only 220. Java has about 340 breeding species, Lombok only 120. It is even more true for freshwater fish: Borneo has 162 species of the carp family Cyprinidae, Celebes has none; Java has 55 species, Lombok has apparently only a single one. Raven (1935) shows that the Mammalian fauna is equally impoverished. The same is true for the Philippines, their fauna is badly depleted, as compared to that of Borneo and Palawan (Dickerson *et al.*, 1928).

THE GEOLOGY OF THE MALAY ARCHIPELAGO

Why the islands Sumatra, Java, Borneo, and Palawan should have a rich animal life, whereas the Philippines, Celebes, and the Lesser Sunda Islands have a poor one, cannot be understood without a study of the geological conditions. The British geologist Earle pointed out, as early as 1845, that geologically the Malay Archipelago consists of three parts, a western one comprising the greater Sunda Islands and the adjoining parts of Asia, which was very stable during the Tertiary, an eastern one consisting of New Guinea and Australia, which was also stable, and an unstable island belt in between. The unstable area, comprising the Philippines, Celebes, the Moluccas, and the Lesser Sunda Islands, has a most complicated geological structure. Deep sea basins, grabens, geosynclines and geanticlines are scrambled together in a bewildering manner. Geologists are still far from agreement in regard to the interpretation of these structures. So much, however, is clear—that this area is highly unstable and that it has seen many and violent changes in the recent past.

Originally, that is in late Mesozoic times, Celebes, the Moluccas, Misol, and western New Guinea, seem to have been situated on the same continental shelf. The fossil marine faunas of the mentioned regions, as well as tectonic features prove this close relationship. In fact, most geologists consider it as well established that Asia and Australia were in broad continental connection up to the very end of the Mesozoic. The Tertiary was a period of very active orogenesis. Part of the Philippines and of northern Celebes seem to have been folded up first. There is some evidence for the existence of additional islands during Eocene and Oligocene, as, for example, in the Timor region, but the exact position, size and chronology of such islands is unknown. In early Miocene, or according to other authors in very late Oligocene, the crust of the

earth seems to have buckled down in a gigantic manner along a line, which is roughly indicated by the west Sumatran Islands, Timor, Kei, Seran, and Halmahera. The very strong negative anomalies of the gravimetric measurements along this line are according to Vening Meinesz good evidence for the occurrence of such an event. The folding was so violent that it resulted in the widespread overthrusting of older strata over younger ones. The so-called outer Banda arc, consisting of the islands Sumba, Timor, Babber, Timorlaut, Kei, Seran, and Buru was formed along part of this fold. All of these islands are geologically very similar. Slightly later, but still in the Miocene, a second fold was formed consisting of parts of Sumatra and Java, as well as of the so-called inner Banda arc (Bali, Lombok, Sumbawa, Flores, Alor, Wetar, Dammer, and Banda). Most of this fold remained, however, at first submerged under the ocean. In fact, some of the islands may not have emerged until well in the Pleistocene. Later in the Tertiary, particularly in the Pliocene and Pleistocene, extensive fault lines developed which led to the lifting of large blocks (marine terraces in Timor rose 1280 m.!) and the corresponding sinking of other blocks to form flat-bottomed deep sea basins. The geological data indicate that periods of violent tectonic activity have alternated with periods of relative quietness, and the frequency of earthquakes and the continuous volcanic activity in this region reveal that the orogenic movements have not yet completely died down. The writings of Molengraaf (1922), Umbgrove (1932, 1934), and Kuenen (1935) should be consulted for further details concerning the geology of this region. Three facts of zoogeographic significance seem to stand out among the geological data: (1) There is no evidence whatsoever for any continental connection between Borneo and Celebes. In fact, the distance between the two islands was, up to the Pleistocene, greater than it is today; (2) Java, Bali, Lombok, and the other islands of the inner Banda arc are situated on the same geanticline; and (3) there is no geological evidence for any cross connections between inner and outer Banda arcs, except possibly between Sumba and Flores.

The first of these three conclusions shows that Makassar Strait is an ancient ocean barrier and that at least this particular part of Wallace's Line is geologically well-founded. Geologists and zoogeographers are in full agreement on this point.

Tertiary geology supplies, however, no explanation for a faunal difference between Bali and Lombok, a difference which seems to be due to events of a more recent geological past. A considerable quantity of ocean water accumulated in the polar ice caps during the Pleistocene glaciations. It has been calculated that this resulted in a lowering of the sea level of tropical ocean by at least 70 m., but more probably by 150 m. This caused the drying up of all shallow seas and resulted in a considerable extension of land on Sunda and Sahul shelves (see Fig. 1). Sumatra, Java, and Borneo united with the Malay Peninsula in the formation of "Sundaland," an extension of the Asiatic mainland and Bali became attached to this continent. Lombok, however, which is separated from Bali by a strait of a depth of 312 m., remained separated, even though it was fused temporarily with Sumbawa.

The geological background of Wallace's Line is thus as follows: In its central part, between Borneo and Celebes, it follows the edge of the continental Sunda shelf, in the south between Bali and Lombok (and the same is true in the north between Borneo-Palawan and the Philippines) it indicates the eastern edge of the Pleistocene Sundaland. The faunal break, which I have shown to exist along Wallace's Line, appears now in a new light. It is due to the fact that the line separates, on the whole, a continental from an insular fauna. This separation is clear cut in Makassar Strait, but it is rather obscured along the Sunda arc, where the geanticline of the inner Banda arc protrudes from Sundaland like a peninsula. Faunal breaks along this chain of islands occur not only on Lombok Strait, but also on all the other inter-island straits. A number of authors, among whom Mertens (1930) is foremost, have contended, that some of the other straits, as that between Java and Bali, or the one between Sumbawa and Flores, are even more efficient distribution barriers than Lombok Strait. This assertion is in conflict with the above-given findings of Pleistocene geology and it becomes therefore necessary to examine the relative efficiency of these water barriers in more detail.

THE EFFICIENCY OF THE WATER BARRIERS BETWEEN THE LESSER SUNDA ISLANDS

The faunal change between Borneo and Celebes is abrupt, but it is much more gradual along the west of Wallace's Line. The number of species

of birds on this island chain is as follows: Sumatra about 440; Java, 340; Bali, 166; Lombok, 119; Sumbawa, 123; Flores, 143; and Timor, 137. In the freshwater fish family Cyprinidae, Sumatra has 115 species; Java, 55; and Lombok only a single one. Of butterflies Sumatra has 334 species; Java, 270 species. Of reptiles Sumatra has 193 species; Java, 136 species (Rensch 1936). It is obvious from these figures that the animal life of Java is considerably impoverished as compared with that of Sumatra (or Borneo). The reasons for this are not entirely clear, but two factors seem to be most important. One is the heavy activity of the Javanese volcanoes, particularly during the Pleistocene, which covered a good part of the island with lava and ashes and may have exterminated a number of localized species. The second and more important reason is that Java is less humid and poorer in habitats than Sumatra, also more peripheral and thus less accessible to colonists from the Asiatic mainland. The climatic deterioration, which is already indicated in western Java, accelerates rapidly in the eastern part of the island where in the lowlands true tropical rain forest seems to be largely replaced by monsoon forest. The result is that many of the most characteristic Java elements (including nearly all of the well-known endemics) are restricted to western Java. Of the 340 species of Java birds only 245 are found in the eastern half of the island and it is reasonable to believe that some 70 of these species drop out before the eastern tip of Java is reached, leaving only about 170 species for the eastern tip of the island. No natural history survey has ever been made of this section of Java. This is unfortunate because the fauna of a small area of easternmost Java, equivalent in size to Bali, must be compared with the Bali fauna, if one wants to test the significance of Bali Strait as a zoogeographic barrier. It would be entirely misleading to subtract the number of Bali species from the total number of Java species and state that the difference comprises the species that are unable to cross Bali Strait. This method was actually applied by Mertens (1930) and Brongersma (1936), who arrived thereby at the erroneous conclusion that Bali Strait was the most important barrier along the Sunda chain.

A faunal change between the western and the eastern end occurs probably not only on Java, but on all elongated islands of the Sunda chain such as Sumbawa, Flores, and Timor. This fact invalidates to some extent the figures on the subsequent calculations, but it is fortunately of minor importance in respect to the small and rather round islands of Bali and Lombok.

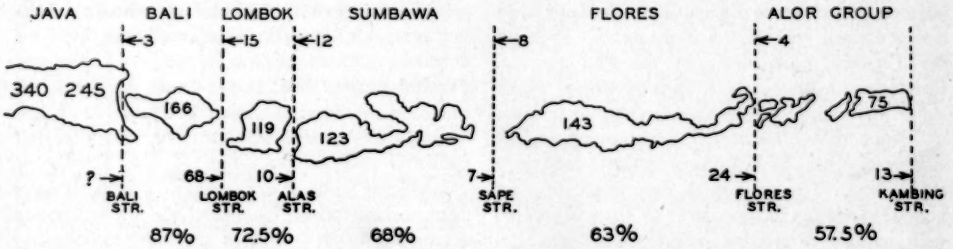

FIG. 2. INTER-ISLAND STRAITS IN THE LESSER SUNDA ISLANDS AND THEIR EFFICIENCY AS DISTRIBUTIONAL BARRIERS FOR BIRDS
Explanation of figures in text.

This is by no means the only difficulty that is encountered in the attempt to determine the relative efficiency of the various straits in the Sunda chain. It happens that there is a gradual but steady change of climate and plant cover from west to east. Each more easterly island is somewhat more arid than its western neighbor and one after the other of the humidity-loving species drops out because the habitat becomes unsuitable and not necessarily because it can not cross the water barrier separating it from the next island.

The effect of six inter-island straits on the distribution of birds is illustrated in Fig. 2. The top line of figures records the number of eastern species that find the western limit of their ranges on the inter-island straits. Lombok Strait shows the highest figure with 15 species, but, on the whole, the difference between the various straits is rather slight. This is not surprising, since all the eastern species have the ability to jump water barriers

and it is probable that the ecological factors on the islands have as much or more to do with the limits of the ranges than age or width of the straits between them. The second row of figures gives the number of breeding species known from each island (the second figure on Java gives the number of species on the eastern half of Java). The third row of figures, and this is the most important one of all, gives the number of western species that are halted by the various straits. The significance of Lombok Strait becomes at once apparent It prevents the passage of 68 (41 per cent) of the 166 Bali species. No other strait approximates this figure. The last row of figures gives the percentage of western species on each of the islands.

The relative efficiency of Lombok, Alas, Sape, and Flores Straits can be expressed by calculating what percentage of the species occurring on either side are stopped by the straits. Lombok Strait, for example, is a barrier for 83 (= 68 + 15) species of a total of 285 (166 + 119), that is, 29.1 per cent. The percentages for the other straits and for a number of other animal groups are given in Table 2.

The figures of Table 2 have, of course, only a relative value since the species totals include many species twice, once east and once west of the straits. Still they are valid as indicators of the relative efficiency of these straits and of their rank. Many of the smaller islands (Penida, Komodo, Sangeang, Rintja, etc.) are insufficiently explored and have therefore been omitted from the tabulation. Solor, Adonara, Pantar, and Alor have been united as Alor group. In the tabulation of the borders of western species only the eastern-most occurrence has been used. This explains a seeming discrepancy of the figures. Flores Strait, for example, stops only 24 of the 143 species on Flores. One would expect the Alor group to have 119 species (143 less 24), but it actually has only 75. The "missing" 44 (119 less 75) species are, however, found on Wetar, Timor, or other more easterly islands, which proves that Flores Strait is not the eastern limit of their range.

The data presented in Fig. 2 and in Table 2 can be summarized as follows: Each of the straits in the Lesser Sunda Islands is a zoogeographic barrier. Lombok Strait, however, is more effective than any of the others. This is apparently due to the fact that this strait persisted throughout the Pleistocene, whereas Bali Strait and Alas Strait dried up at the height of the Pleistocene glaciation. Rensch's data (Table 2) indicate that reptiles, amphibia, butterflies, and land mollusks show similar conditions as birds and it is possible that a more thorough exploration of Bali, Flores, and Alor would make the two sets of data even more similar. Mertens (1930), for example, who denies that Lombok Strait is a more important barrier than Bali or Sape Straits, bases this claim on a study of the very insufficiently known herpeto-fauna of Bali. De Beaufort (1926) and other students of freshwater fish are also handicapped in a discussion of this subject, since with few exceptions there are no true freshwater fish east of Lombok Strait. Even Bali has a badly depleted fish fauna. That this island is so poor in freshwater fish is not really surprising, since it is a volcanic island and has not a single large and only one medium-sized stream. It would be dangerous to base too many conclusions on the distributional data derived from a single group which is so exacting in its ecological requirements as are freshwater fish.

Freshwater fish are useful as negative zoogeographic indicators. The fact that primary freshwater fish (see Myers, 1938, for a definition of this term) are absent from Seran and Kei indicates, for example, that these islands have had no continental connection with New Guinea. The presence of four species of freshwater fish in the Lesser

TABLE 2

Relative efficiency of straits in Lesser Sunda Islands

	BIRDS (ORIG.)	REPTILES, AMPHIBIA BUTTERFLIES AND LAND MOLLUSKS (RENSCH)	RANK (FOR BIRDS)
Lombok Strait (Bali-Lombok).....	83 of 285 = 29 per cent[1]	84 of 377 = 22 per cent	1
Alas Strait (Lombok-Sumbawa).....	22 of 242 = 9 per cent	34 of 367 = 9 per cent	3
Sape Strait (Sumbawa-Flores).....	15 of 266 = 5.5 per cent	52 of 364 = 15 per cent	4
Flores Strait (Flores-Alor).....	28 of 218 = 13 per cent		2

[1] This figure indicates what percentage of the sum of the species of the two islands on either side of the strait have not crossed the strait.

Sunda Islands—*Rasbora elberti* on Lombok and Sumbawa; *Clarias batrachus* on Bali, Lombok, and Sumbawa; *Aplocheilus javanicus* on Lombok; and *A. celebensis* on Timor—does not necessarily prove continental connections for these, but it casts doubt on the means of dispersal of these species. The slight, or absent, differentiation of these species demands that these islands had a recent continental connection. However, if such had existed one would expect a much richer fish fauna. The transport of fish by water spouts is well substantiated and it is also possible that Lombok Strait had occasionaly a surface sheet of freshwater while it was the outlet for the large streams of Pleistocene Sundaland. It would be dangerous to go too far in such speculations of possible chance dispersal but it is even more dangerous to base sweeping zoogeographic conclusions on the presence of a few species of so-called freshwater fish.

THE EASTERN COUNTERPART OF WALLACE'S LINE

It is obvious that there must be a line at the eastern edge of the island belt which corresponds to Wallace's Line in the west. Such a line would separate the zone of a more or less pure Australo-Papuan mainland fauna from the islands to the west with an impoverished Papuan fauna and an Indo-Malayan admixture. This line has been vaguely referred to by Lydekker and other nineteenth century writers, but I believe de Beaufort (1913) was the first to point out its true significance. It is not difficult to trace since it follows, except for a short stretch in the north, the 100 m. depth line, that is, the edge of that part of the Sahul shelf that was dry land at the height of the Pleistocene glaciation (Fig. 1). It passes between the Aru Islands, which have a pure Papuan fauna, and the Kei Islands with an impoverished fauna with Oriental elements. Of birds, for example, 166 species are known from the Aru Islands, including birds of paradise and many other typical Papuan types, while only 84 species are known from the Kei Islands, including some western elements. The line then passes between the mainland of New Guinea and Seran Island. There are 115 species of birds (about 30 per cent western) known from Seran as against more than 300 species from the Vogelkop, the neighboring part of New Guinea. The line that separates the Papuan mainland fauna from the island fauna swings from Seran north and passes through the Gilolo passage separating the western Papuan Islands (Waigeu, Batanta, Salwati, and Misol) from the Northern Moluccas. In this section the line does not follow entirely the 100 m. contour, which would exclude Koffiau, Gebe, Batanta, and Waigeu. However, all these islands are so purely Papuan and form such a well-defined faunistic unit that it seems justified to be slightly inconsistent. It might be worth while to emphasize that the line, as just drawn, gives a better defined delimitation of the "Papuan mainland" and "Papuan island" fauna than does Wallace's Line in the west for the Indo-Malayan fauna. Its validity is particularly apparent for all groups with a limited dispersal faculty, for example freshwater fish. De Beaufort's map (1926, p. 103) of the range of the subfamily *Melanotaeniinae* illustrates it quite graphically. This Australian group extends westward as far as the Aru Islands and Waigeu, but is absent from the Kei Islands and from the Northern and Southern Moluccas.

The significance of this eastern line has been emphasized by a number of authors. It indicates, like Wallace's Line, a major faunal break; it separates, like its western counterpart, a continental from an island zone, as well as a zone with a more or less undiluted Papuan fauna from a mixed Papuan-Oriental fauna, a contrast which is least apparent in the north. It is for all these reasons that this line must be considered a major zoogeographic boundary.

SHOULD AN INTERMEDIATE ZOOGEOGRAPHIC REGION BE RECOGNIZED?

A gradual transition between the Oriental and the Australian faunas takes place in the island belt between Wallace's Line and its eastern counterpart. This was realized quite clearly by Salomon Müller (1846), the earliest zoogeographer of the Malay Archipelago. He lists correctly "Celebes, Flores, Timor, Gilolo and perhaps Mindanao" as islands on which a mixture of Indian and Australian elements is found. Wallace also, in his later publications, admitted the intermediate position of this region and stated of Celebes that it "hardly belongs to either [Oriental or Australian] region." Pelseneer (1904:1007) lists a whole group of workers who recognized the transitional character of this region.

There are other factors, in addition to the lack of continental connection, which contribute toward the poverty of the fauna of this island belt. Salomon Müller (1846) very ably pointed out some

of the reasons, such as the small size of most of the islands, their low elevation and their aridity. There is a more or less arid corridor extending from the Philippines and Celebes to Buru and to the Sunda Islands from eastern Java to Timorlaut. This zone has acted as a barrier to many humidity-loving forms and has prevented their passage from Sundaland to the Papuan Region or vice versa. Additional reasons for the faunal poverty of this zone are the young geological age of many of the islands, which limits the number of chance colonizations, and the heavy volcanic activity over part of the region. There are three lines of volcanoes in this transition zone, one extending from Sumatra through Java to the inner Banda arc, a second one following the western edge of the northern Moluccas, and a third one reaching from north Celebes through the Sanghir Islands to the Philippines. The volcanic activity is thus strictly localized, but where it occurs it may be a very serious factor indeed. As mentioned, it seems to be one of the reasons why Java's animal life is so much poorer than that of Borneo or Sumatra (Rensch, 1936). There are not only 59 young volcanoes of more than 2000 m. altitude on Java, but also many extinct late Tertiary ones. This factor is even more evident on Lombok where heavy Pleistocene eruptions of Mount Rindjani seem to have destroyed much of the mountain fauna. The same is true for the volcano on Ternate Island (Stresemann, 1939:381).

All the mentioned factors combine to give the fauna of the transition zone a peculiar character. This has impressed some of the authors to such an extent that they have proposed to give formal recognition to this fauna and elevate the island belt to the rank of a separate zoogeographic region or subregion.

Dickerson *et al.* (1928), who coined the term *Wallacea* for this region, and Rensch (1936), who simply calls it *Zwischengebiet* (region of intermediacy), are the two most recent champions of such an arrangement. This region would include four different groups of islands, (1) the Lesser Sunda Islands from Lombok eastward; (2) the Moluccas and other outliers of the Papuan Region (Tenimber, Kei); (3) the Celebes group (with Sula and Talaut); and (4) the Philippines. Two reasons are usually quoted in favor of recognizing such a transition region. One is, that many endemic species and genera are confined to it. The other reason is, that all of the islands, which are included in this transition zone, are populated by a mixture of Indo-Malayan and Australo-Papuan elements. As against these points which would favor the recognition of a transition region there are some very strong objections. Pelseneer (1904) has stated them clearly. He points out that it is only natural that

> a zoogeographic border is not a line without width and that by necessity there is a mixture of faunal elements along the border of two zoogeographic regions, caused by a reciprocal penetration.
>
> But if one would admit for this reason a special 'transition region' or a 'region of intermediacy,' one would obviously double the difficulties of delimitation. For now it would be necessary to trace both of the border lines which separate the transition region from either of the two adjoining zoogeographic regions.

These difficulties of delimitation are fully confirmed by the two most recently proposed transition regions. Dickerson *et al.* (1928:297) define theirs as follows: "Wallacea is outlined sharply by Wallace's Line (as modified) on the west and Weber's Line upon the east." It thus includes the Philippines, but it excludes the Moluccas, Timorlaut, and Kei Islands. Rensch (1936:265), however, includes in his *Zwischengebiet* "Celebes, the Lesser Sunda Islands, Timorlaut (perhaps also Kei), and the Moluccas (at least the southern Moluccas)." He definitely excludes the Philippines. Celebes and the Lesser Sunda Islands are, thus, the only two districts which the two transition regions have in common.

The "degree of intermediacy" of the various sections of the transition region is very uneven. It seems, for example, that the percentage of Australo-Papuan species in the Philippines (which are included in Wallacea by Dickerson and Merrill) is smaller than the percentage of Oriental species in New Guinea or Australia. Still, nobody would want to suggest including Australo-Papua in the transition zone.

Stresemann (1939:403) adds another weighty objection. He points out that the transition zone comprises four separate districts which have much less in common with one another than each one has with some outside region: The Moluccas are faunistically closest to New Guinea, and Celebes to the Philippines, but the Philippines are closer to Malaysia than to Celebes. The Lesser Sunda Islands, finally, have a close faunal relationship with Java and Australo-Papua, but only a very slight and recent one with Celebes. To unite four such heterogeneous districts in a single "region"

violates all principles of regional zoogeography. After all, if a zoogeographic region means anything, it means the home of a more or less homogeneous characteristic fauna. "Wallacea", however, is the home of four different faunas. It is self-evident that the formal recognition of a zoogeographic region of such heterogeneity is neither practical nor scientifically defensible. The term transition zone is justified only if applied informally as a descriptive attribute.

WEBER'S LINE

It is apparent from the preceding discussion that neither Wallace's Line nor the formal acceptance of a transition zone are satisfactory attempts of delimiting the Oriental against the Australian Region. This leaves, to my mind, only one other alternative solution, namely, the recognition of a line east of Wallace's Line. Before attempting to draft the best possible course of such a line, a few words must be said about the validity of any zoogeographic borderline.

A zoogeographic region is usually defined as a geographic subdivision of the earth that is the home of a peculiar fauna. Such a region is characterized by the presence of many endemic genera and families and by the absence of the characteristic genera and families of other zoogeographic regions. Its border should be drawn along the line where this specific fauna is replaced by a different fauna. This procedure is logical and presents no difficulties in all the cases where an efficient barrier separates the two regions, such as is formed by the South Atlantic between Africa and South America. However, an intermingling of the two faunas takes place in a border zone whenever two such regions come into direct contact. This is exactly what has happened in the island belt between Asia and Australia. Both the Indo-Malayan and the Australo-Papuan mainland faunas have spilled over into the intermediate island belt and it might seem impossible to delimit in such a mixed region one fauna from the other one. However, as Pelseneer (1904) says correctly, "it is evident that there must be a line . . . within the region of mixture, on one side of which the faunal elements of one region prevail and on the other side those of the second region. This line can serve usefully to mark the borderline between the two biogeographic regions."

On the basis of these considerations Pelseneer established a borderline between the Oriental and the Australian Regions, which he called "Weber's Line." Pelseneer drew the course of this line on the basis of non-zoological data, that is, primarily on the soundings and other oceanographic results of the Siboga Expedition, many of which are no longer valid today. However, Weber's Line actually separates the islands with a more than 50 per cent Indo-Malayan fauna from the islands with a more than 50 per cent Papuan fauna, as is evident from Rensch's (1936) careful data and from all the other zoogeographic work of the region. With insignificant modification the line suggested by Pelseneer is still acceptable as the best possible borderline between the Oriental and the Australo-Papuan Regions.

The course of Weber's Line (Fig. 1) is as follows: In the north it begins between Talaut and Celebes in the west and the northern Moluccas in the east. In this section the line is extremely well defined, since the fauna of the northern Moluccas consists of about 80–90 per cent and that of Celebes of about 20–40 per cent Papuan elements. The line continues from here between the Sula Islands in the west and Obi in the east and then swings around Buru. The fauna of the Sula Islands is insufficiently known, but it is close to that of Celebes except much poorer and with a stronger Moluccan element. Still the Papuan component is probably less than 40 per cent, while it is about 63 per cent on Buru and even higher on Obi. It is difficult to trace Weber's Line from Buru on. Pelseneer attempted to follow the contour of the ocean bottom and this caused him to run the line between Banda ("Indo-malayan") and Seran ("Papuan") and between Sermatta ("Indo-malayan") and Babber ("Papuan"). The much more detailed information on the fauna of these islands, which is now available, indicates that a different course might be preferable. The young volcanic Banda Islands have a fauna which almost completely lacks endemic elements, and which is very close to that of Ambon, Seran, Seranlaut, etc. There is no doubt that the Banda Islands must be included in the southern Moluccas. Babber, on the other hand, has a fauna which is closer to that of Dammer and Sermatta, than to that of Timorlaut. It is, therefore, preferable to place the line between Babber and Timorlaut. Rensch (1926:206) has already pointed out the impossibility of separating Babber from the closely related Sermatta and Dammer. The fauna of Timorlaut is about 62.5 per cent Australo-Papuan. South West Islands, from Roma and Kisar to Dammer and Babber are a faunistic unit, but the progressive decrease of Indo-

Malayan elements which started on Java and Bali continues on these islands. It is possible that a future analysis may show that the eastern element on Babber and Dammer is already slightly more than 50 per cent of the total fauna of these islands. Even then I would be inclined to retain them in the Oriental Region rather than to draw a line through the middle of the South West Islands.

One glance at the map shows that Weber's Line is situated much closer to the Australo-Papuan than to the Asiatic shelf. The reason for this is twofold, faunal pressure and accessibility. The faunal pressure of the Indo-Malayan fauna is greater than that of the Papuan fauna because it is much richer in species and families. The sphere of influence of this rich fauna will, therefore, extend farther into the island belt than that of the poorer Papuan fauna. The second reason is that the chain of the Lesser Sunda Islands, forming practically a peninsula of Sundaland, was infinitely more easily accessible to colonists from the west than to those from the east, which had to jump the wide gap either from Australia to Timor or from New Guinea (and Aru) to the islands of Banda Sea. The preponderance of Oriental species in the Lesser Sunda Islands would be even more pronounced if ecological factors (aridity) had not favored colonization by Australian elements. These various factors explain the present course of the line of faunal balance, Weber's Line. Wallace's argument that Celebes should be included in the Australian Region because it had so few Oriental species as compared to Borneo, is beside the point. Every true island has, of course, a much impoverished fauna, but its zoogeographic position is determined by an analysis of its existing fauna and not by the elements it lacks. With an 80 per cent Oriental fauna Celebes can not be included in the Australian Region!

Weber's Line has found curiously few adherents among zoogeographers; Boden Kloss (1929) is one of the exceptions. There is nothing spectacular about this line and by crossing it one encounters a smaller faunal change than is found between Borneo and Celebes, or between New Guinea and Seran, or in general between the "mainland" and the "island" faunas (Fig. 1). The difference between the faunas of Sula and Buru and of Babber and Timorlaut is, indeed, rather small. Weber's Line is not acceptable to those who look for a strikingly conspicuous borderline between the Oriental and Australian Regions (Rensch, 1926:265).

Other objections have been raised against Weber's Line. Some authors, for example, have objected to Weber's Line because it separates islands which lie on the same submarine ridges. Thus it cuts between Babber and Timorlaut, between Dammer and Banda, and between Sula and Obi, each of these three pairs of islands lying on the same submarine ridge. It seems to me that this argument is another instance of confusing zoogeographic and geological interpretations, exactly as in the case of continental versus oceanic islands (Mayr, 1941). The geology of an island, and particularly of an oceanic island, is of no concern whatsoever, when we are attempting to classify its fauna. If the fauna of Seran and Kei is prevailingly Papuan, I shall classify these islands with the Papuan region. The fact that Timor and Sumba with a prevailingly Indo-Malayan fauna lie on the same tectonic arc has absolutely no bearing on this decision. In fact there is no evidence that any of these arcs were ever raised to the extent that they were exposed for their full length, and it is obvious that the undersea geology can have no influence over the distribution of forms that are dispersed across the water.

De Beaufort (1926:184) also rejects Weber's Line for a purely geological reason, because "the Moluccas are not the remains of a former greater land mass." This argument is entirely irrelevant, not only since Pelseneer nowhere makes such a claim, but also because the former geological history has a bearing on zoogeographic classification only to the extent to which it influences present day distribution.

I know of only a single valid argument against the adoption of Weber's Line as the boundary between the Australian and the Oriental Regions. It is the objection against dividing arbitrarily any continuous series of values at the halfway point between the extremes. In the case of Weber's Line the situation is aggravated by the fact that the 50:50 balance between the Indo-Malayan and the Australian elements is not always the same in the various taxonomic groups. The bird fauna of Wetar Island, for example, is more than 50 per cent Australo-Papuan, while in other groups the Oriental element seems to prevail. On Celebes about 67 per cent of the birds are of western origin, while among mammals, butterflies, reptiles, amphibians, and land snails it is more than 80 per cent. On the whole it seems as if among reptiles and butterflies the western element pushes farther eastward than among birds and snails. However, taking the

fauna as a whole, Weber's Line seems to separate rather neatly the islands with a prevailingly Oriental fauna in the west from the islands with a prevailingly Australo-Papuan fauna in the east. As stated above, the easternmost of the South West Islands (Dammer and Babber) possibly have slightly more than 50 per cent Australo-Papuan elements, but it is inadvisable to separate them from the larger group of islands of which they are an integral part. Lines of 50:50 balance face even more difficulties on continents than in archipelagos. The line in North America on which the Palearctic and the Nearctic elements balance, would be entirely unsuitable as a zoogeographic boundary. A 50:50 line is, thus, admittedly a more or less arbitrary boundary and may have to be modified in special cases. But it is no more arbitrary than to accept March 21st as the first day of spring (regardless of the weather!), or the 21st birthday as the day on which an adolescent reaches seniority. Such rigid divisions are of practical usefulness not only in human affairs, but frequently also in scientific matters. Different faunal regions are generally indicated on zoogeographic maps by different colors. It is obvious that the 50:50 line is the most convenient place where to replace one color by another. It is in this sense that Weber's Line (as modified above) may be accepted as the boundary between the region with a prevailingly Oriental and the region with a prevailingly Australo-Papuan fauna.

UNSOLVED PROBLEMS OF INDO-AUSTRALIAN ZOOGEOGRAPHY

The conclusions at which I arrived in the present analysis are not final. Many of the islands are insufficiently explored and it is certain that future exploration will add a good deal to our knowledge. A further refinement in the zoogeographic methods is also expected to yield increased results. Salomon Müller, P. L. Sclater, A. R. Wallace, and other early representatives of the classical school of zoogeography selected arbitrarily a number of indicator species and based the outlines of the zoogeographic regions and subregions on the distribution of these species. The preferred technique of the present paper is to calculate in percent the proportion of faunal element in the total number of species of certain localities. All the percentages in Fig. 2 and Table 2 are derived by this method.

In the matter of faunal composition an even superior method might be to determine the faunal relationship of the dominant species of each habitat. It seems, for example, to judge by Rensch's description (see above) that the differences between the dominant species of birds of Bali and Lombok is even more striking than is apparent from a statistical analysis of the total faunas. Such a comparison of the dominant types of local faunas must be based on accurate census data gathered in the field and such data are not yet available. To gather them would be a worth while task of future explorers of the Malay archipelago.

The combination of ecological and zoogeographic methods promises to yield data of considerable interest. It seems, for example, that the faunal composition of each habitat is different. Of the eleven species of birds that are restricted to the mountain forest of Timor (above 4000 feet) only a single one is Papuan, the other ten are Indo-Malayan. The ratio is even, if not reversed, among the birds of the tree savanna of Timor. Lack of exact ecological data prevents a more accurate analysis at the present time. Steenis and other botanists have shown that a similar difference of floristic composition exists between different plant associations. Here is a practically untouched field for future investigators.

The delimitation of biogeographic regions depends to a considerable extent on the dispersal faculties and on the nature of the speciation processes of the organisms of which the distribution is studied. It has become evident in recent years that there is much difference between phytogeographic and zoogeographic classifications. The major floristic regions coincide fairly well with the major climatic regions. The major zoogeographic regions, on the other hand, indicate primarily the extent of formerly (or currently) isolated land areas. The biogeographic classification of New Guinea is a good illustration for this. New Guinea is, for the phytogeographer, a part of the Malayan region, but faunistically it is at least as close or even closer to Australia. A comparison of phytogeographic and zoogeographic maps indicates that it is impractical at the present time to construct biogeographic maps, that is, maps that intend to illustrate simultaneously the distribution of plants and of animals.

This is equally true, although to a lesser extent, for animal groups with different dispersal faculties. I have already mentioned above the differences between birds and reptiles in regard to the faunal composition of some of the islands. Much more accurate data are needed. It is possible that some

of the invertebrates show a distributional pattern that is much more similar to that of plants than to that of mammals or birds. Progress in this field depends largely on a more thorough faunistic exploration of the Indo-Australian Region.

SUMMARY

(1) Wallace's Line is not the boundary between the Indo-Malayan and the Australian Regions, but rather it indicates the edge of the area (Sunda shelf) that was dry at the height of the Pleistocene glaciations.

(2) The equivalent line along the edge of the Sahul Shelf separates New Guinea and the Aru Islands from the Moluccas and Kei Islands.

(3) Weber's Line separates the islands in the west on which the Indo-Malayan element is predominant from the islands in the east on which the Australo-Papuan element has a numerical superiority.

POSTSCRIPT

The results of an important symposium on Wallace's Line and on the zoogeography of the Indo-Australian archipelago (Scrivenor, *et al.*, 1943) have been published after the completion of the present work. These papers contain nothing that would require a major modification of the conclusions at which I have arrived above. However, they contribute a considerable amount of interesting factual data and raise a number of questions which I have not treated. Corbet (*op. cit.*) shows that Weber's Line, at least in its northern part between Celebes and the northern Moluccas, constitutes a more pronounced faunal division in several families and genera of butterflies than Wallace's Line in its most effective section (between Borneo and Celebes). Malcolm Smith (*op. cit.*) comes to the conclusion, on the basis of the distribution of vertebrates, that Weber's Line is preferable to Wallace's Line, if a single borderline between the Oriental and the Australian Regions is to be found. The botanical contributors emphasize the discrepancy between the classification of biogeographic regions of the zoologists and of the botanists. This disagreement is much less striking in regard to the minor divisions.

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THE SENSORY BASIS OF BIRD NAVIGATION

By DONALD R. GRIFFIN

FEW natural phenomena have excited more wonder, guesswork, and debate than the long distance flights of migratory birds. Many species travel thousands of miles from breeding grounds to winter range, often crossing hundreds of miles of open ocean. Some young birds apparently make their first migration without adults of the same species to guide them.

The central problem is one of navigation: how does the bird know where to fly? Some receptor or receptors must be excited by an aspect of the bird's environment which is related to the direction of its goal. Visually perceived landmarks constitute one such aspect of the environment, but there are many migrations in which some other type of orientation must be involved. For instance, some birds cross large bodies of water in cloudy weather when no landmarks are visible, while in other species the young migrate before they have had an opportunity to learn anything about the route. It seems, at first glance, that those aspects of the environment which are functions of the geographical relationship between the bird and its goal are outside the sensitivity range of its receptors. Are unsuspected geographical cues available to birds, or is their sensory spectrum more extensive than we know?

No completely satisfactory answer to this question can yet be given, for direct studies of migration have seldom passed beyond the descriptive stage. Valikangas (1933) has shown that ducks raised in Finland from English eggs migrated south in their first autumn with Finnish birds and that several returned the next spring to their "foster homes" in Finland. This experiment indicates a lack of any inheritance committing the bird to a specific route. Thienemann (1930), Skovgaard (1929), and Schenk (1909) reared young storks in captivity and released them in the autumn after most wild storks had departed. Several of the young birds were recovered on or not far from the species' normal migration route. Rowan (1931) reported similar results with crows, although Drost (1939) found that when young sparrowhawks were treated in this way, they generally remained near the point of release. These experiments confirm the ornithologists' impression that young birds of many species can make their first migratory flight without the guidance of experienced adults.

Rowan (1932, 1938a, 1938b), Schildmacher (1933, 1934), Wolfson (1941), and others have studied the effects of endocrine secretions on the *time* of migration They have learned much about the internal stimulus necessary to initiate migration, but such studies have not thrown much light on the sensory processes by which birds guide themselves on long migratory flights.

Most of our knowledge of the sensory basis of bird navigation has been obtained from homing experiments; for in these experiments it is possible to control, to some extent, the conditions under which the bird is to make its long distance flight. Consequently this review will be concerned almost entirely with such work. The term "homing" has been used to cover (1) return of birds shipped in captivity to a distant release point, and (2) a natural migratory flight, often hundreds of miles long, in which birds leave one region and then return to it the following season. Austin (1940) and Stoner (1941), for example, have used the term in the latter sense, while Thompson (1926) and others have made a sharp distinction between what might be called "natural homing" and the "artificial" homing experiments, such as those described below, in which birds are captured, shipped to a distance and released. Among the "artificial" homing experiments should be included the remarkable feats of the domestic and non-migratory racing pigeon. It seems reasonable to assume with Warner (1931) that the same or similar means of navigation are used in both types of homing, and furthermore that if we knew how a bird finds its way home when shipped 1000 miles from its nest, we should be in a better position to explain annual migratory flights of similar extent.

Many other animals have migrations comparable

in length and difficulty to those of birds, and some have a pronounced homing ability. But it seems best to limit this discussion to the birds, where the phenomenon has reached its greatest development and where it has been most studied. Several review papers have discussed the homing of birds, one of the earliest being Claparède's "*La faculté d'orientation lointaine*," published in 1903. Watson and Lashley (1915), Warner (1931), and Schüz (1931) have reviewed the literature; and there have been partial reviews by Mayr (1937), Alexander (1938), and Thompson (1936 and 1939). But several papers have appeared recently and certain theoretical problems can now be formumulated more clearly.

Some homing ability has been found in almost all birds which have been tested; but different species vary widely in speed of return and in the proportion which return at all. In general, migratory species have greater powers of homing than sedentary birds with restricted individual ranges. In practically all homing experiments birds are taken from nests or mates, or at least from breeding areas; for they are much less likely to return to other regions, such as a winter feeding range (Hilprecht, 1935; Rüppell and Schifferli, 1939; Odum, 1941; Gillespie, 1930; Sumner and Cobb, 1928).

In order to provide a compact and comprehensive picture of the homing ability as we know it, the results of the more extensive homing experiments on record have been summarized in Table I. The distances are great circle "air lines," disregarding natural barriers which, in a few cases, probably necessitated long detours by the returning birds. Sometimes only a portion of the birds listed in a paper are included because the remainder were released in poor physical condition or because the data were incomplete. A question mark indicates that the figure cannot be ascertained from the published record. The experimental conditions were often not good enough to enable prompt recording of all birds which returned, so that the homing performances listed in the table are *minima*. In any experiment it is possible that a larger proportion of the birds returned, and that some may have flown home faster than the records indicate. Table I is not a complete summary of the literature, although it contains data from more than 1686 transported individuals, exclusive of pigeons. However, to the best of the writer's knowledge, no experiments have been omitted unless they involve extremely short distances, very few returns, small numbers of birds, or the publication of incomplete data as to speed and percentage of returns.

There is considerable variability in speed and percentage of returns, both of which are important criteria of homing ability. With some birds, such as herring gulls, this is partly due to weather conditions (Griffin, 1943; Woodcock, 1940a, 1940b); but this explanation may be less applicable to birds which are less dependent upon updrafts. Another fact which should be mentioned is the very poor homing from *short* distances which has been noted with petrels (Griffin, 1940a), herring gulls (Goethe, 1937; Griffin, 1943), terns (Watson and Lashley, 1915), swallows (Loos, 1907), and even with bats (Griffin, 1940b). This may be an important clue to the sensory basis of homing—it might, for instance, mean that there was a relatively constant time required for orientation, an interval which is independent of the distance—but to date there is no satisfactory explanation for the fact that several species seem to require little more time to return from 75 to 100 miles than from 10 or 15 miles.

Claparède (1903) and Watson and Lashley (1915) list numerous theories to account for the sensory basis of navigation during such feats of homing as those enumerated in Table I. I shall not discuss those such as "telepathy" and "tropisms" which lack experimental support, which did not seem promising to these earlier reviewers, and which have not been seriously advanced since. The explanations which have received most attention are critically discussed below under three headings: *theories involving* (1) *vision;* (2) *kinaesthetic receptors;* and (3) *postulated magnetic or electrical receptors*. In the final section, entitled *Discussion and Speculations*, an attempt is made to combine several theories, both old and new, into a composite working hypothesis of the sensory basis of homing and migration.

THEORIES INVOLVING VISION

The hypothesis that the nest or its immediate surroundings are perceived directly (Hachet-Souplet, 1909, 1911) can be ruled out by the distances involved in most of the experiments listed in Table I. Watson and Lashley (1915) have presented evidence that, even under the most favorable circumstances, birds' visual acuity would not permit perception of landmarks at more than 100

TABLE 1
Homing abilities of various birds

REPORTED BY	SPECIES	DISTANCE SHIPPED (*Miles*)	TOTAL NO. OF BIRDS	PER CENT RETURNS	SPEED OF RETURN (*Miles per day*)	
					Slowest	Fastest
Rabaud (1928), Watson and Lashley (1915), Rivière (1923, 1929), Gibault (1930), and many others	Racing pigeons	Up to 2000	Thousands	Variable	Up to 1000*	
Watson and Lashley (1915), Watson (1915), and Schüz (1931)	Noddy and sooty terns	70–855	53	72	6	142
Dircksen (1932)	Arctic tern	22–255	16	63	28	278*
Griffin (1943)	Common tern	94–456	80	43	28	350*
Griffin (1943)	Herring gull	15–872	176	93	2	715*
Goethe (1937)	Herring gull	8–228	24	96	1	143*
Griffin (1940a)	Leach's petrel	13–470	147	66	2	93
Lack and Lockley (1938, 1939)	Manx shearwater	125–930	36	53	1	300*
Rüppell (1934a, 1935, 1936, 1937)	Starling	12–1160	704	26	6	220
Rüppell (1934b, 1936, 1937)	Swallow (H. rustica)	172–1160	56	40	14	256
Wodzicki and Wojtusiak (1934)	Swallow (H. rustica)	Up to 75	10	70	?	480*
Gillespie (1934)	Rough-winged swallow	33	1	100	—	65*
Rüppell (1934b, 1936)	House martin	320–450	26	27	110	236
Rüppell (1937)	Wryneck	213–937	19	32	17	78
Rüppell (1937)	Red-backed shrike	225–750	12	8	—	58
Alexander (1938)	Rook	65–90	120	2	?	?
Fox (1940)	Cowbird	80–184	4	100	13	54
Gillespie (1930)	Cowbird	20	1	100	—	120*
Lyon (quoted in Grosvenor and Wetmore, 1932)	Cowbird	620–1200	?	?	21	71
Manwell (1941)	Red-winged blackbird	2–210	133	35	0.1	12
Rüppell (1937, 1940)	Goshawk	57–338	46	7	?	?
Wimsatt (1940)	Duckhawk	60	1	100	30?	30?
Stimmelmayer (quoted by Schüz, 1931)	Bluethroat	275	17	12	1	17
Wodzicki, Puchalski and Liche (1938)	White stork	188–1410	?	75	?	116
Schifferli (1942)	Swift	12–40	9	78	?	413

* Flights lasting less than 24 hours.

miles. Furthermore, the altitudes at which birds ordinarily fly and the curvature of the earth's surface limit vision to 100 miles at best. Watson and Lashley also presented evidence that the eyes of chicks and pigeons are not sensitive to infra-red light, which is said to be refracted around the

curvature of the earth more easily than the visible rays. Thus refraction cannot be called upon to explain the phenomena of homing, although it is always possible to argue that wild migratory birds might have a more extensive visual spectrum than chicks or pigeons.

Yet there are some types of homing which can be ascribed, without straining our credulity, to the use of visual cues. All birds wander for considerable distances from their nests or from territory which they customarily occupy during the non-breeding seasons. A strong flier may well have become acquainted in this way with a wide area. For instance, Woodcock (1940a, 1942) has given evidence that herring gulls range far out to sea in their daily search for food, especially during the breeding season. There is no reason to believe that other large birds may not have equally extensive ranges. This area within which a bird may orient itself by means of known visual landmarks is conveniently defined as its "familiar territory." It is indeed difficult to account for the normal daily movements of birds without assuming an ability to recognize ordinary landmarks and orient themselves thereby. This assumption is in harmony with the relative importance of vision as compared with other senses in the general behavior of birds and with the good pattern discrimination which Gundlach (1933) has shown in pigeons. Homing from within a bird's familiar territory thus presents no sensory problems comparable to those raised by some of the flights outlined in Table I (in particular the return of Watson and Lashley's terns and Lack and Lockley's shearwaters from release points which were probably outside the range of the species). For this reason no attempt has been made to review here the numerous homing experiments on record involving short distances.

Where no familiar topographical cues are available, the bird might nevertheless find landmarks useful in the process of orientation. The sun, moon, and stars, or river systems and coastlines might, under some conditions, provide guidance even though they lie outside the bird's familiar territory. This type of visual cue is discussed in the final section of the present paper.

Another theory based on vision assumes that when birds are taken outside of their familiar territory they do not fly directly home but make extensive exploratory flights in search of landmarks they have previously seen during migrations or spontaneous wanderings. In one type of exploration, which I shall call "radial scattering," each bird is assumed to fly in approximately a straight line in any direction which may take its fancy. This theory seems to have been first advanced by Claparède (1903) who suggested that if one released a large group of birds in unknown territory one might expect them to scatter in all directions like the spokes of a wheel. Only those which happened to head in the general direction of home would eventually enter familiar territory, orient themselves visually and continue directly to their nests (see Fig. 1—solid lines). Under these circumstances one might expect that a rather small percentage of the birds would reach their nests, but that these few would return almost as rapidly as though they had flown straight home. The percentage of returns would be proportional to the angle subtended at the release point by their familiar territory. (See Claparède (1903) and Roberts (1942) for detailed estimates of the percentage returns to be expected.)

In a second type of exploration it is assumed that the birds fly in a large spiral so that the distance between the successive loops of the spiral is approximately twice the distance at which landmarks could be recognized. If this process were continued long enough, familiar territory would eventually be reached. This type of hypothetical behavior for a homing bird might be called "spiral exploration" (see Fig. 1—dotted line). It was first described by Hodge (1894), but it has received little attention in recent years. Where the bird is carried a considerable distance beyond familiar territory the total time required for a return flight should be much greater after spiral exploration than after the radial type, but eventually *all* the birds flying the spiral course might be expected to return, instead of only those which chanced to take the correct direction in radial scattering. If the bird explored by following the most efficient spiral course, the approximate total distance can be expressed by the following equation:

$$D = \frac{\pi D_u^2}{R} + D_f$$

where:

R = distance between the loops of the spiral
D = total distance flown
D_u = air line distance from release point to nearest familiar territory

D_f = distance from edge of familiar territory to home. (See Fig. 1 for graphic representation of these quantitites.)

In very long homing flights the time of return should, if the bird is using spiral exploration, vary approximately as the *square* of the total distance. But it is important to note that this relationship holds only if D_u is large relative to R and D_f.

Actually no bird is likely to follow so simple a path as either of those described above, and we might expect some sort of a mixture of the two—such as initial scattering for a few miles followed by spiraling or vice versa. Topography would no doubt influence the bird's spiraling, and it would not be necessary for it to survey every square mile of unknown territory. In fact, a third type of exploration, theoretically the most efficient of all, would be an extremely large spiral in which R (the distance between the loops) was approximately equal to the diameter of the bird's familiar territory (D_f). For the bird need not seek a point, as the simple theory of spiral exploration assumes, but rather a large area—the whole expanse of its familiar territory. If a bird could fly such a course, it could return much more rapidly than predicted by the above calculation. But the navigational problem of flying in these large spirals would be, in itself, a difficult one for which to find a sensory basis. Birds often fly in small circles near the point of release, but the large scale spiraling required by this theory has never been observed.

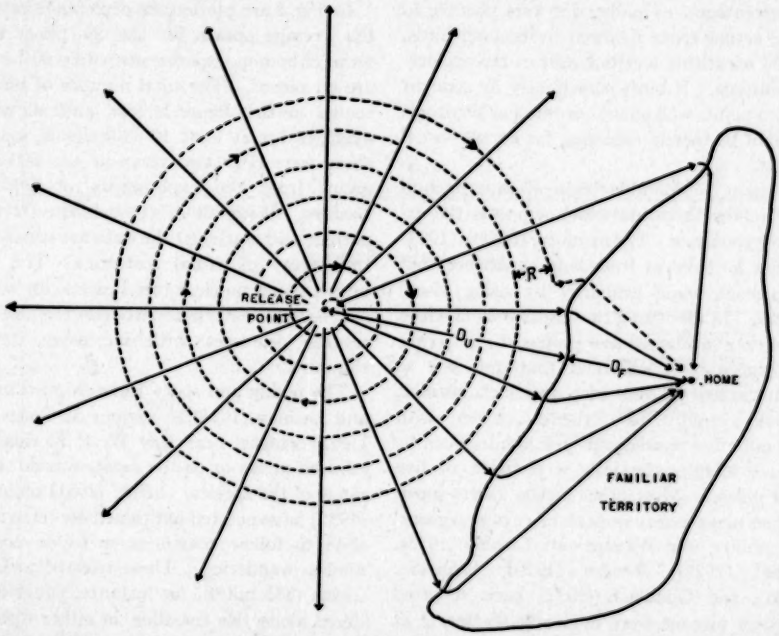

FIG. 1. HYPOTHETICAL FLIGHT PATHS OF BIRDS HOMING BY MEANS OF RADIAL SCATTERING (SOLID LINES) AND SPIRAL EXPLORATION (DOTTED LINES)

In this diagramatic instance five out of sixteen birds reached home by means of radial scattering, flying courses 1.03, 1.04, 1.18, 1.67, and 1.71 times the straight line distance $D_f + D_u$. The bird homing by spiral exploration would have flown approximately 13.3 times the straight line distance.

Perhaps the most credible theory of homing by exploration would involve a radial scattering upon which might be superimposed detours related to topography and some small scale circling or spiraling such as is often observed immediately after a bird's release. Many of the homing experiments on record have yielded results which are quite compatible with such a theory of exploration. The first prerequisite of such compatibility is either a low percentage of returns or an average homing speed far below the bird's ordinary

velocity of flight, even allowing a reasonable time for rest and feeding. Secondly, if birds are finding their way by exploration, they should home much faster from within their familiar territory than from points outside of it. A third test is to recapture birds which have already returned from a release point outside of their familiar territory and then set them free again in the same region. If familiarity with visual landmarks is an important aid to homing, the birds shipped a second time to the same release point should return faster and in higher percentages. Finally, if it were possible to trace the actual route followed by homing birds, this would constitute a critical test of the exploration hypothesis. If birds consistently fly straight home from points well outside of familiar territory, they cannot be merely exploring for known visual landmarks.

There is a considerable body of experimental evidence in the literature which supports the exploration hypothesis. For instance, Rivière (1923) states that he believes from long experience that racing pigeons home primarily by using visual landmarks. In discussing the mysterious faculties which various authors have proposed, he writes "Every pigeon racer will agree that were one to credit untrained pigeons with any such instinct, one would rapidly lose them. . . . Even with training only five pigeons out of a hundred can be got to negotiate successfully a distance of five hundred miles." Most other pigeon racers agree that vision plays a very important part in pigeons' homing ability (see Watson and Lashley, 1915).

Rabaud (1928), Rivière (1929), Schneider (1905–06), and Gundlach (1932) have reported cases where pigeons were evidently scattering at random from a release point in strange territory. The clearest example is from France (Rabaud, 1928; also quoted by Warner, 1931): ". . . Out of 1500 pigeons released at 312 miles (at sea), 300 returned at the end of 48 hours; the others were found scattered everywhere, in England, Spain, Portugal, Algeria, Cape Verde, Egypt and in the Caucasus . . . one conceives . . . of birds wandering at hazard and finally encountering some landmark which puts them on their way." Other cases where pigeons may have been flying a spiral course are described by Hodge (1894), Dusolier (1903), and Anonymous (1873). Dusolier writes that releases of pigeons at great distances result in:

"enormous losses, first returns at the end of 15 to 20 days . . . beyond 625 miles the results which pigeons give one are very uncertain; the time required for return (when they do return) is not proportional to the distance but in general because of the difficulties of orientation it follows an enormously more rapid progression; 625 miles can with difficulty be covered in a day, for 940 miles 15 days are required, for 1250 a month is needed. . . ."

Gundlach (1932) also believes that an initial radial scattering is followed by "a course that is on the average reducible to an ever widening spiral (as long as the pigeon is in strange territory)."

In Fig. 2 are plotted the percentage returns and the average speeds for the five most extensive series of homing experiments with wild birds which are on record. The total number of birds represented in this figure is 996, and all points are averages for at least 10 individuals, except that there were only two terns in the 600–800 mile group from the experiments of Watson and Lashley. With all of these birds, (terns, gulls, petrels, and starlings) the data are consistent with the theory of radial scattering. The speed of return shows no clear trend except for an increase of speed up to 100 miles, whereas the percentage of returns decreases with increasing distance of shipment.

The noddy and sooty terns shipped by Watson and Lashley (1915) to various distances from the Dry Tortugas, near Key West, Florida, were all released at sea or on the coast, outside the normal range of the species. Schüz (1931) and Gundlach (1932) have pointed out that these terns had ample time to follow coastlines or to do considerable aimless wandering. Those released at Galveston, Texas (855 miles), for instance, could have wandered along the coastline in either direction and eventually reached territory which they had visited before in the course of their migrations. Terns are rapid fliers and can cover three hundred miles per day (Griffin, 1943), so that only the very first returns need necessarily have flown home at all directly. These could have been using a modification of the radial type of exploration described above.

Common terns (Griffin, 1943) returned from as far as 456 miles, but the percent returning dropped with distance (see Fig. 2), and the performance was consistently worse from unfamiliar territory than from points along the birds' normal migration route. Herring gulls (Goethe, 1937; and Griffin, 1943) also homed well from as far as 872 miles. The data show a questionable ten-

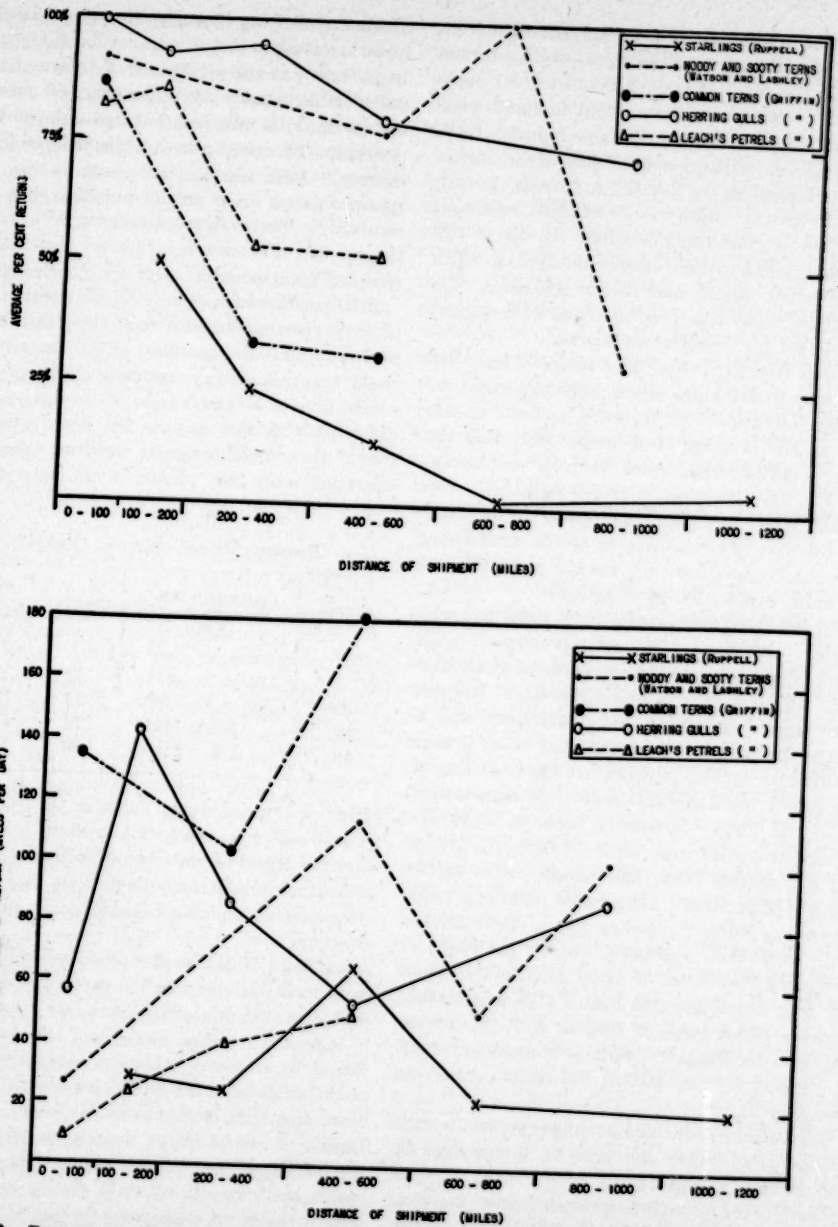

FIG. 2. PERCENTAGE RETURNS AND AVERAGE SPEEDS OF HOMING EXPERIMENTS WITH WILD BIRDS

In the upper graph percentage returns from five series of homing experiments are plotted against distance of shipment. In the lower graph is plotted the *average speed* of return in these same five series of homing experiments. Note that percentage returns almost always decrease with distance of shipment while speed of return shows no clear trend at all.

dency for better homing from familiar than from unfamiliar territory, and three gulls which returned very slowly when shipped 250 miles from home showed a very great improvement in speed when shipped a second time to the same region. Gulls and terns were released on both sides of the narrow isthmus separating the Bay of Fundy from the Gulf of St. Lawrence. Both species returned somewhat faster and in greater numbers from the side of this isthmus nearest to their home—the side on which the coastline would offer better guidance. On the whole, these data from terns and gulls suggest exploration for familiar landmarks.

Petrels (Griffin, 1940a) have returned from distances up to 470 miles at sea, but the percent returning decreased with distance, and the speeds were so low (average 28 miles per day) that the birds would have had ample time for exploration (see Fig. 2). The time of return seemed to vary approximately as a linear function of the distance; and this fact, plus the drop in per cent returning from the longer shipments, fits the predictions of the radial exploration hypothesis.

Rüppell (1934, 1935, 1936, 1937, 1938) has conducted extensive homing experiments with starlings, swallows, and other species of small land birds which show less homing ability. Rüppell used larger numbers of individual birds and a greater diversity of species than any other worker in this field; and his papers mark the beginning of the recent trend toward large scale experiments with wild birds. Somewhat fewer of Rüppell's starlings returned from areas through which they did not migrate than from release points to the south of their nests. The average number of miles covered by Ruppell's starlings per day (about 30) is little more than a starling can fly per hour, so that they may have deviated considerably from the true course towards home. The relationship between speed, percent returns and distance of shipment for Rüppell's starlings is consistent with the theory of exploration by radial scattering (see Fig. 2).

Rüppell also conducted homing experiments with swallows; and they can best be summarized in tabular form (Table 2).

Some of the more distant release points (London, 563 miles; and Madrid, 1160 miles) were almost certainly outside the previous range of these individual swallows. Yet these birds can fly 60 m.p.h. for a short time at least, so that the distance covered per day would account for only three to five hours of flying time provided they had flown home in a straight line at their normal flying speed. In no case was the percentage of returns from a considerable distance anywhere near 100 per cent, and at the 1100 mile points it had dropped to 20 per cent. The speed of return was independent of distance. Both starlings and swallows may have returned faster or in greater numbers than were recorded, for observations at the nest were not continuous, but it is not safe to assume that such unrecorded returns would alter the conclusions.

If Rüppell's swallows were familiar with a band of territory extending southwest along their migration route (see Neithammer, 1937), these returns could be explained by assuming radial or spiral exploration or a combination of the two. But a difficulty with this explanation lies in the fact that if they could recognize territory along their migration route they should home faster and in higher percentages from points on this route than from completely unknown territory. Yet only a part of Rüppell's data shows such an effect, and he has concluded that both starlings and swallows must have an undefined *Richtungssinn* or sense of direction.

TABLE 2.

Homing ability of swallows (Rüppell)

NUMBER OF BIRDS	DIRECTION AND DISTANCE (*Miles*)	PER CENT RETURNS	AVERAGE SPEED (*Miles per day*)
7	W × S— 475	72	37–188
8	W × S— 563	25	116–141
10	S.E.—1125	20	141–161
10	S.W.—1160	20	145–166

Rüppell (1938) also attempted a homing experiment with starlings raised in captivity. The birds were captured as nestlings, and raised to maturity in cages. They then nested and raised their own young in captivity. During incubation several of the adult breeding birds were taken from their nests and eggs, and released at about 70 miles. Despite a careful watch no returns were seen in the vicinity of the "home" cages. The only part of Rüppell's results which is clearly inconsistent with a theory of exploration by scattering is the recovery of three starlings en route quite close to the true course home (see below).

Loos (1907) and Wodzicke and Wojtusiac (1934) have also reported homing experiments with

swallows, but most of the distances were less than 100 miles; and the results were essentially similar to those described by Rüppell. Wodzicke, Puchalski, and Liche (1938) sent storks from Poland S.E. as far as Palestine. Their speed of return did not diminish with distance as predicted by the exploration hypothesis, but the birds may have been familiar with the route from previous migrations. The data have not been published in full.

The homing experiments reported by Dircksen (1932), Goethe (1937), Lack and Lockley (1938), and the others listed in Table I did not involve enough individuals to test the quantitative speed-distance predictions of the exploration theory; but in all save one or two cases (see below) the birds returned at such low average speeds that they could have deviated considerably from a true course home.

While the results of all the homing experiments described above can in general be considered consistent with the exploration theory, there are other instances where it seems definitely insufficient. For instance, the distance of shipment of racing pigeons is sometimes increased suddenly from 500 to 1000 miles, and the birds which return from such flights cannot have used visual landmarks during the first half of the return flight. Rivière (1923) reports that one pigeon returned 501 miles in one day (49 m.p.h.) although it had been trained over but 80 miles of the route. Oordt (1929) describes cases in which pigeons which had previously returned from 375 miles east of their home were released 300–375 miles to the south, and yet were able to home with the same speed. In almost all cases where racing pigeons are suddenly carried to greater distances than ever before, they are released in large flocks where the inexperienced birds may follow those which have flown the course before. It is not stated whether this was the case with most of the records cited above.

However, Thauzies (1910) reports that 62 pigeons were released at 210 and 265 miles without any previous training at or near the release points. Practically all came home, within 5 hours to 4 days, the great majority returning during the day following their release. The exact extent of their previous training and familiar territory is not stated, but it would have to be large to explain these results on the basis of exploration. Gundlach (1932) reports exactly the opposite phenomenon—when birds trained on a north-south course were carried 100 miles west (across a mountain range) they returned very slowly and several were lost. But in this case the mountains, rather than difficulties of orientation, may have been responsible for the poor homing.

Petrels (which are strictly marine birds) seem to have returned directly over 18 miles of land rather than follow a much longer salt-water route, although the evidence for this is scanty and unsatisfactory (Griffin, 1940a). Such an overland short-cut by petrels could scarcely be the result of exploration. Also, there is the case of a shearwater, reported by Lack and Lockley (1938), which would have had little time for exploration while it was returning from Venice to Wales in 14 days (over 260 miles per day, assuming that it followed the water, or 68 miles per day if it flew across country over the Alps, a most unlikely feat for a strictly marine bird like the shearwater). This record is all the more remarkable since the Mediterranean is probably outside the range of this sub-species of shearwater.

Clearly the best way to appraise the importance of exploration would be to actually trace the route followed from release point to home. If the majority follow essentially a straight line or detour only for topographical reasons, then they cannot be merely exploring—they must have some specific sensory cue to the correct bearing of home.

In most homing experiments the birds scatter in all directions from the release point and show little or no tendency to take the correct direction, at least until after they are out of sight. However, there are a few recoveries or observations en route which indicate the actual course followed by homing birds.

Gibault (1930) reports that 39 pigeons were trained only in the vicinity of their loft and then released at 118, 138, and 188 miles. The returns were rather few; 13 came back to the home loft at speeds ranging from 15 miles per *hour* to 18 miles per *day*. But of the 26 which did not return 6 were reported from other lofts which they visited in the course of their search for home. All of these six recoveries were within 45° of a straight course. Rüppell (1937) cites three cases in which his starlings were retaken en route, and none of them showed any important deviation from a straight course. One of these three starlings had been shipped 500 miles directly south and was within the winter range (familiar territory?) of birds breeding near its home (Neithammer, 1937).

Another bird had been set free 200 miles E.S.E., probably outside of familiar territory, since the birds migrate S.W. in fall, but it may have returned by following the valley of the Elbe on which both home and release point were situated. The third starling, however, was shipped 251 miles N.E. and released in all probability in strange territory where no landmarks were available. In neither Gibault's nor Rüppell's experiments is there any indication that these results are due to a more intense search for recoveries along the true course than in any other direction.

Eight herring gulls have been traced for five miles or more of their return route by observation from hilltops and from airplanes (Griffin, 1943). Five of these were released in central Massachusetts, 100 miles or less from their home colony; and they may well have been able to find familiar territory rather quickly. The behavior of the first bird, released at Grafton, Mass., and followed for 37 miles, suggests random searching for familiar landmarks. This bird flew downwind for the better part of an hour, flying in circles with much zig-zagging until it came within sight of the ocean. From this point on it headed directly towards the salt water until it was lost to view near the shoreline. Two birds released at Orange, Mass., drifted downwind, which happened to be in exactly the direction of home. Two others flew due south from Orange, deviating 45° from the true course. Two gulls released a few miles south of Montreal, in unfamiliar territory, 290 miles from home, headed directly away from home for 5 to 7 miles or as far as they could be kept under observation. Finally, a bird released on Lake Erie stopped for at least three days at Toronto (on Lake Ontario) while returning to its nest on the coast of Massachusetts. (This bird was observed by Mr. and Mrs. J. M. Spiers who knew nothing of the experiment at the time but later furnished a sufficiently accurate description of the paint marks on the bird that it could be identified with certainty.) Its deviation from a true course was 45°, but the long delay at Toronto may indicate that it traveled fairly straight when it was actually moving.

It is clear that many more return routes of individual birds must be traced by direct observation or by recoveries en route before this question can finally be settled. Exploration may play an important part in the homing of many birds, particularly when speed or per cent returns are low; but it does not seem capable of accounting for all the recorded cases.

THEORIES INVOLVING KINAESTHETIC RECEPTORS

Kinaesthetic theories of the sensory basis of homing have been advanced by Exner (1893, 1905), Bonnier (1903), and Meise (1933). When carried away from the nest, even in a closed box, the bird is continually being stimulated by pressures and accelerations imparted to his body by the box. All these accelerations may arouse proprioceptive, kinaesthetic, and inner ear labyrinth sensations. Theoretically a bird might be able to deduce from these sensations the general direction in which he was carried, but it seems incredible that he could remember every twist and turn of a long journey. Furthermore, birds have been transported under anaesthesia or in continually rotated cages, and have returned as well as untreated controls (Exner, 1893, 1895; Kluijver, 1935; Griffin, 1940a, 1943). However, these rotation and anaesthesia experiments have been done only in cases where the birds were released in territory with which they may have been familiar, and from which they could perhaps return by means of visual landmarks or by exploration.

Rotation or anaesthesia experiments have yet to be done under conditions where one could be certain that the birds did not orient themselves by exploration. Exner's pigeons and Rüppell's or Kluijver's starlings were all released less than 100 miles from their nests. Four rotated herring gulls released at 240 miles did not show any significant increase in homing time (Griffin, 1943); but their average homing speed was but a small fraction of their known velocity of flight, indicating that both experiments and controls may have been homing by exploration. The petrels which the writer (1940a) rotated during part of their transportation to sea may have located the coastline by such general landmarks as the direction of the rising sun, and found their particular island by means of known visual landmarks along the coast.

Sobol (1930) and Huizinga (1935) have reported that pigeons whose semicircular canals have been injured or destroyed can still home as well as normal controls. However, the birds were shipped only 25 miles or less, so that both controls and experimentals may have been using visual landmarks.

Thus the kinaesthetic theories cannot be said

to be completely disproved, but the accuracy and complexity of kinaesthetic or labyrinth memory required are so extreme that the hypothesis cannot be seriously considered unless direct supporting evidence is produced in the future.

THEORIES INVOLVING POSTULATED MAGNETIC AND ELECTRICAL RECEPTORS

Various theories of orientation by means of a postulated magnetic sense have been much discussed in the scientific literature on the homing instinct (1) Viguier, 1882; (2) Caustier, 1893; (3) Thauzies, 1898, 1904, 1910, 1913; (4) Maurain, 1926; (5) Casamajor, 1926, 1927; (6) Stressmann, 1935; (7) Daanje, 1936 and 1941. A simple magnetic compass would not aid the bird without some cue as to the direction in which its home was located. Furthermore no sensitivity to a magnetic field has been demonstrated in any animal, and sensitivity to as weak a field as the earth's is made extremely unlikely by the fact that living tissues are not known to contain any of the very few *ferrimagnetic* substances (such as metallic iron, magnetic iron oxide or magnetite, nickle and cobalt) which alone are capable of exerting appreciable mechanical forces in the earth's magnetic field.

The more complex theory of Viguier (1882) involving sensitivity to differences in dip and intensity of the earth's magnetic field requires an extremely low threshold to such fields. A further fundamental weakness in Viguier's theory is that the lines of equal dip (inclination) of the earth's field and the (isodynamic) lines of equal intensity (isodynamic lines) both run roughly parallel to the earth's equator, so that even if a bird were sensitive to both of them it would not have a grid of intersecting lines to guide it as Viguier suggests. The dip and intensity are the only known variables of the earth's magnetic field which could come into play (declination is the difference between the true and the magnetic north—a meaningless quantity, of course, unless the bird could take sights on the north star!).

Nor do any birds move rapidly enough to induce, while flying through the earth's field, voltages known to be capable of stimulating any living tissue (see also Maurain, 1926). Attempts (unpublished) to train 3 homing pigeons to respond to a magnetic field were entirely negative, although the field used was of considerably greater intensity than the earth's field. Even after as many as 570 trials there was no evidence of response to the magnetic field, although under the same conditions the birds could learn to respond to light in 20 to 70 trials and to a draft of air in about 50 trials.

There would be a very slight tendency for the dipolar molecules throughout a bird's body to orient in the earth's magnetic field, and conceivably some extraordinarily delicate chemical equilibrium might be upset by changes in the direction of this tendency to orient. Furthermore, it is conceivable that there are particles in animal tissues which act as "magnetic ions," such as those described by Ehrenhaft and Banet (1942). These possibilities are admittedly far-fetched, but failing other solutions of the problem of bird navigation, those interested should watch for developments along such lines in the physical chemistry of biological substances.

There has recently been much rumor in popular publications about interference with the homing of pigeons and the migrations of wild birds by radio stations (Brown, 1938; Casamajor, 1927; Darling, 1940; Aymar, 1935; and Maurain, 1926). The writer knows of no statistically significant data supporting such opinions, and it seems appropriate to neglect them until they are adequately tested.

DISCUSSION AND SPECULATION

After reviewing the experimental evidence derived from artificial homing experiments, it seems clear that many of the observed phenomena of homing are consistent with the assumption that birds merely explore until they find familiar visual landmarks; but in other cases this hypothesis requires a good many extenuating explanations or appeals to coincidence. The principal evidence against exploration as the sole basis of homing is (1) that in some cases birds seem to return from totally strange territory too rapidly to have deviated far from a straight line course and in too high percentages to be accounted for by radial scattering; and (2) that a few homing birds have been recovered en route fairly close to the straight course home. Although birds deprived of kinaesthetic cues by rotation or anaesthesia during transportation have homed as well as untreated controls, this does not necessarily disprove the kinaesthetic theory; for in all such experiments recorded to date, the birds may have found their way home by

means of exploration and visual landmarks. The chief argument for the kinaesthetic theories as well as the magnetic and radio-electric theories is the failure of others to account for all the observed facts.

Theories of homing are thus of two sorts, those postulating new and unknown senses, usually involving magnetism or electricity; and those assuming that the birds have approximately the same sensory equipment as ourselves. The second type assumes that the bird merely makes better use of cues available to birds and men alike. The first group, including the magnetic theories, has received serious attention only because the second has seemed entirely inadequate. This abandonment of known senses may have been premature, however, for there are certain theoretical explanations of homing, other than those discussed above, which do not require that one postulate unknown receptors. They are based on the assumption that birds use combinations of sensations from known receptors. Although first suggested long ago, these theories are generally overlooked, and it seems worthwhile to restate them in the light of recent experimental data. An attempt will be made below to outline three general types of explanation which seem promising, and to suggest how each theory might be tested.

Celestial landmarks

Birds might know that the direction of sunrise and sunset were related to the geography of the area in which they were released, an idea suggested long ago by Romanes for insects, and subsequently substantiated by Wolf (1927). For instance, the gulls, terns, and petrels which I have shipped inland and to sea, respectively, might know that the sun set towards shore and rose towards the open ocean. If so, and if they are capable of flying in approximately a straight line for long periods, they could return by this method towards the coastline, much of which is probably familiar territory. Aside from the use of inner ear receptors, a straight-line course might be maintained by means of wind direction, direction of wave movement, or of topography. There is some question as to how a bird could detect the direction of the wind while in flight. Aside from visual judgment of drift and the movement of waves and vegetation when the bird is flying near the ground, there may be gusts and irregularities in the wind which would be perceptable as accelerations imparted to its body. (See Williams, 1930, p. 383.) Of course a uniform flow would not be felt by a bird flying within it, for all his motion is relative to the air.

Thus a Massachusetts herring gull released at Chicago might be influenced by the direction of sunrise to fly east overland from Lake Michigan, keeping to this direction by reference to the wind. On reaching Lake Erie it might follow this shoreline and that of Lake Ontario or other lakes and rivers to reinforce the sunrise or sunset cues until familiar territory was reached.

Cloudy weather would of course make the use of the sun's direction quite impossible (and neither migration nor homing requires clear skies). But celestial landmarks might, in the course of the various homing experiments on record, have carried a large proportion of the birds to familiar territory. Releases at different times of the day, on cloudy days and on clear days, and releases across an isthmus into an entirely unknown ocean might furnish critical tests of this theory. An accumulation of direct observations of return routes from the air would also eventually support or disprove this hypothesis.

It is reported that pigeons home poorly on cloudy days, and in pigeon races the birds are almost always released early in the morning. A pigeon racing club customarily ships all its birds in the same direction regardless of the length of the race. This procedure has proved empirically to produce the most rapid return flights with fewest losses, and it may do so partly because it is the best routine to teach birds that the course towards home bears a definite relationship to the position of the rising sun.

Atmospheric conditions

There is a possible relationship between birds and the weather conditions which, although it is still merely a matter for speculation, may prove to be of great importance. Birds might react to such phenomenon as prevailing winds and the characteristics of air masses. These are aspects of the environment bearing a certain relation to geography. This idea is not new (Toussenel, 1853; Cathelin, 1910; Drost, 1929; McCreary, 1934) but recent advances in meteorology enable one to advance concrete proposals capable of test.

Consider, for example, the writer's homing experiments with herring gulls (1943). Except for very exceptional weather, the area of the experiments (northeastern United States) is alway

covered by one of four or five distinct air masses. These air masses, as recognized by meteorologists, differ in the region of their origin, in their temperature and humidity, and in the rate of change of these two elements with altitude. Temperature and possibly humidity could be perceived by the birds, and there is even a remote possibility that dust, pollen content, or other factors might enable them to distinguish such different air masses as "Polar continental" and "Tropical gulf." There is a certain regularity in the alternation of warm and cold air masses in the northeastern United States. They are separated by zones of rapid temperature change known as "fronts," and clouds of rather distinct types often occur along such fronts. These air masses and fronts almost always move in an easterly direction.

In other words, the prevailing winds of this area are westerlies, the east winds being for the most part local or of short duration. At altitudes above 1000 feet the prevalence of westerlies is even more pronounced than at the ground. There is a further constancy to these common types of air mass movement. South and southwesterly winds commonly mean warm, moist air flowing from the south, while northwest and north winds are usually associated with an arrival of cold dry "Polar continental" air. The first type is usually stable (poor soaring), while the second is likely to involve convection updrafts which facilitate the flight of soaring birds such as gulls. In addition to the wind direction, the direction of arrival of certain cloud types might afford cues to the direction of movement of air masses.

It does not seem unlikely that herring gulls living on the Atlantic coast of the United States might know that cold winds with strong convection usually come from a direction perpendicular to the coastline (N.W. winds), and that a humid, stable air mass usually moves parallel to the coastline or obliquely toward it (S.W. winds). If this should be the case, the birds would have a useful clue to the direction of their home even when released far inland in totally strange surroundings. It is obvious that the same sort of relationship could easily occur in other areas, especially in the lower latitudes where one encounters trade winds of great constancy.

Possible tests of this hypothesis lie in the study of data from homing experiments under various weather conditions, perferably with direct observation of the actual return route. For example, if a cold air mass is traveling in a totally abnormal direction (as sometimes happens) would birds be led astray?

Ecological cues

Another source of geographical cues for homing birds would be an ability to identify various large areas by their climate, appearance from the air, their topography, flora, or fauna. Birds might recognize the relationship of these areas to territory around their home. When released inland they might tend always to fly downstream as soon as they found a watercourse. They might conceivably recognize areas of characteristic vegetation such as (in the case of gulls from Massachusetts) evergreen forests of the Canadian zone, or hardwoods of the Upper Austral and Transition zones. They might have had previous experience with the relationship of such vegetation types to the ocean, to the direction of sunrise or sunset, or to the prevailing movements of characteristic air masses. Some of the gulls mentioned above might have previously flown inland, upwind, in a cold unstable air mass to the evergreen forests and lakes with a Canadian zone fauna and flora. All these elements are well within the range of a gull's perception. If suddenly released from a closed box in totally unfamiliar territory of the same ecological type, in a similar air mass, might the bird not return by soaring downwind just as it had previously done in the course of its natural wanderings?

This type of orientation has little chance to operate when the birds are taken into totally strange environments, as when Atlantic coast herring gulls are released on the Great Lakes or Welsh shearwaters are set free at Venice or in the Swiss Alps. But there have been relatively few successful returns from such releases, and geographical relationships may well be important clues for birds in homing from 100 to 300 miles release points, even if returns from very long distances must be explained otherwise.

One can reasonably assume without postulating unknown senses that birds with a pronounced homing ability can do at least some of the following: (1) fly in approximately a straight line for long distances (using wind direction, visual landmarks such as topography, sun or stars, and also perhaps their inner ear labyrinth); (2) orient themselves by visual memory of landmarks when they reach familiar territory; (3) know that *inland*

from a familiar coastline may mean *toward sunset* or *toward sunrise*; (4) know that streams run toward the coastline; (5) know that certain vegetation types are found in definite directions from their homes; (6) realize that the prevailing winds, especially above 1000–2000 feet may blow from land to ocean or vice versa; and that cold dry air with good soaring usually comes from one direction while moist, warm stable air comes from another. If none of these cues were available, the birds might explore for landmarks, using either of the two types of exploration described above. (The words "know" and "realize" are used here, without intending any anthropomorphic connotations, to mean that birds probably react to these relationships so as to orient themselves correctly in their flight home.)

If these possible cues to the direction of the goal are considered individually each one can be proved inadequate for some cases. Conversely, there are few if any homing experiments which cannot be explained by assuming the operation of one of the processes described above. Pending the very desirable direct testing of these hypotheses, or the suggestion of others, their single or joint use by homing birds seems to be a reasonable working hypothesis.

Any or all of the cues described in this section could equally well be used during migration. For instance, the habits of the common tern in Eastern North America might be stated as an "instinct," in the meaning defined by Lashley (1938), to fly quartering downwind along the coastline in late summer during clear cool days with strong convection (Polar continental air mass with NW winds). This habit would also involve flying upwind on the humid overcast days with smooth air when southerly winds are prevalent. Topographical features along the Atlantic coastline might also be important sensory cues to guide the migration. When the latitudes of the trade winds were reached, one would have to assume that the behavior pattern changed to one of flying cross wind. This hypothetical case is obviously a great over-simplification—but it should serve to illustrate the fact that adequate sensory cues of the sort discussed above are probably available to migrating birds.

There has been considerable study of the correlations between the *time* of migratory flights and the prevailing weather conditions (Thompson, 1926); but little attention has been paid to the possibility that conditions within certain air masses could afford cues to guide the direction of a bird's flight.

Drost (1939) has already shown that winter movements (*Zwischenzüge*) of birds along the coast of Germany were closely correlated with the type of air mass present. When warm air masses covered the area the birds moved a short distance north-eastward (in the direction of their normal spring migration). Conversely, cold air masses produced large flights to the southwest. McCreary (1934) has reported a case in which atypical wind directions during May resulted in an altered migration route of several small land birds. Much more could probably be learned by additional comparisons of available migration data with an adequate series of properly analyzed weather maps. Direct observation of homing and migrating birds from the air is already possible, and it will probably be facilitated by post-war improvements in light airplanes and helicopters. It seems reasonable to expect rapid advances in the study of migration when such direct observations are correlated with air mass meteorology and the present accumulation of ornithological records.

Many will be skeptical that birds could make use of the geographical cues discussed above to perform long and successful migrations without older birds to guide them. This is admittedly a puzzling problem, especially in the case of young birds making their first migration unaided by adults, but one should consider that birds spend their life in the air, and that topography and atmospheric conditions are probably perceived with the compelling simplicity of everyday experiences. The first migration of a young bird may be no more difficult to explain than the inherited ability of a bird (or spider) without previous experience to build an intricate nest whose size and shape is characteristic of the species.

SUMMARY

1) The literature on artificial homing experiments with wild birds and racing pigeons is critically reviewed. All of the experiments involving long distances and reasonably large numbers of birds are summarized in Table I. This table shows species, distance of shipment, number of birds involved, percent returns, and average speed.

2) Several theoretical explanations of the sensory basis of homing are discussed together with the evidence *pro* and *con*.

3) It is concluded that many, but not all, of the homing experiments on record could be explained by assuming that when released in unfamiliar territory the birds scatter at random and explore until they find familiar landmarks.

4) There is no direct evidence to support the kinaesthetic theories, which assume that the birds remember the direction in which they were transported by means of sensations derived from the mechanical accelerations imparted to their bodies during transportation. In several experiments birds have been transported under anaesthesia or rotated *en route* with no resulting impairment of their homing ability. However, in all of these experiments the homing performance of both experimentals and controls could have been achieved by exploration so that these experiments may not have been testing the kinaesthetic theory at all.

5) The various theories assuming sensitivity to the earth's magnetic field or to electric fields or to electromagnetic radiations are supported by little or no experimental evidence. The chief argument in their favor seems to be the lack of any other satisfactory explanation of the sensory basis of homing and migration.

6) In speculating about the methods birds might use to find their way home from unfamiliar territory, three generally overlooked types of cue seem worthy of attention:

(a) Birds might know the relationship between geographical features such as river systems and coastlines near their home and the direction of sunrise, of sunset, or conceivably of other celestial landmarks.

(b) Typical air masses may be recognizable by birds, and the prevailing winds within them are often sufficiently constant to serve, in conjunction with topography, as a very useful cue to the direction of a bird's home.

(c) A homing bird may be aware of the relationship between the territory familiar to it and other ecological and topographical regions, such as river systems, coastlines, vegetation types, or faunal zones. This would permit such types of orientation as a sea bird familiar with the coastline flying downstream to known coastal landmarks when released in unfamiliar inland territory.

7) The combined use of familiar landmarks, together with simple geographical, meteorological, and ecological relationships such as those described above seems more reasonable as an explanation of migration and homing than the postulation of a new sense organ.

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HORMONES IN THE CRUSTACEA
THEIR SOURCES AND ACTIVITIES

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I. INTRODUCTION

HORMONAL activities in invertebrate animals have been suspected for many years. The early suspicions were with regard to the development and maintenance of secondary sexual characters, a matter which even today is one of the most controversial subjects in invertebrate endocrinology.

Until the third decade of this century nothing in the way of concrete information had been obtained. In 1922, however, Kopéc demonstrated very strikingly that the brain of *Lymantria* was the source of a hormonal substance regulating pupation in this form. In 1928, Perkins working with *Palaemonetes* and later in the same year Koller working with *Crangon* (*Crago*) reported excellent evidence to show that the eyestalks contained a source of hormonal material responsible in part for the remarkable adaptive color changes in these animals. During the last ten years considerable progress has been made in exposing the extensive endocrine mechanisms which exist in the Insects and the Crustacea. Other invertebrate groups have as yet been investigated relatively little and the results obtained are hardly more than suggestive. Reviews of this rapidly growing field of invertebrate hormonal mechanisms have appeared from time to time. They have included those by Koller (1929), Hanström (1937c), Koller (1938), Lelu (1938), Hanström (1939), von der Wense (1938), and Scharrer (1941). More recently, due to the increasing volume of literature upon the subject there has been a growing tendency to review separately the situation for the two most investigated groups. Thus reviews for the crustaceans alone have been prepared by Brown (1939a, 1941) and by Kleinholz (1942).

In examining the field of crustacean endocrine physiology one is impressed with the similarity of the general processes involved with what has been found for the vertebrate. Thus, in both vertebrate and crustacean we find control of chromatophores, growth and related processes, various aspects of general metabolism, and reproductive mechanisms. Information on the specific nature of the relation of hormones to these processes in crustaceans has in most cases hardly more than commenced to accumulate. There is, furthermore, much reason to believe that there is still considerable pioneering work left to be done before even the crude framework of the endocrine picture of these animals will have been completed. Fundamental discoveries are constantly being made. There are organs such as the X-organs which, judging from their histological picture, are definitely endocrine in nature, but for which there has been as yet, not even a guess as to their function. On the other hand there are processes which there is good reason to believe are hormonally influenced and for which such hormonal sources are quite unknown. Of the hormones whose sources and certain activities are now fairly well known, we know almost nothing of their normal chemical nature nor of the control of their production.

Perhaps one of the most promising fields of the immediate future is that of hormone production by central nervous organs. There is growing reason to suspect that certain hormonal functions analogous to those performed by organs morphologically distinct from this system in the higher vertebrates are in actuality being performed by tissues within the nervous system of crustaceans.

We shall let these remarks suffice for a general introduction to the topics to follow. For the first time an attempt has been made to consider crustacean endocrinology by hormone sources as is customarily done for the vertebrates. Hitherto, the reviews have been organized typically by general

processes believed to be hormonally controlled. There are certain advantages to each method of presentation. The one adopted here was chosen in an attempt to put the crustacean information more in line with the vertebrate, thus making it more easily accessible to vertebrate endocrinologists.

II. THE SINUS GLAND

The crustacean sinus gland was first described by Hanström (1933). Since then it has been described in some detail for a large number of species, representing widely different groups, by Sjögren (1934), Hanström (1937a), Ståhl (1938a, b), and Carstam (1942). In fact, the gland seems to be so generally found that there is good reason to believe it is present, without exception, at least in all higher crustaceans. This gland lies in the eyestalks of most stalk-eyed crustaceans. Exceptions to this last include *Gebia* and *Hippa* and certain other Anomura in which the gland lies in the head in close proximity to the brain. In eyestalkless species the gland lies in the head beside the brain.

According to Hanström (1937b), the gland in its most primitive form occurs in the Mysidacea where he has described it for *Eucopia* and *Boreomysis* as a latero-ventrally located disc-shaped differentiation of the neurilemma enclosing the nervous elements of the eyestalk. The gland is bounded externally by the large principal blood sinus of the stalk and internally by ganglion cells. The gland is penetrated by minute canals which pass from the gland to the large blood-sinus. Both gland and canals appear charged with inclusions which stain intensely with eosin, acid-fuchsin, or light-green. Such a simply formed gland appears also to be found among the Euphausiacea (Hanström, 1939), and in the isopod, *Oniscus*, and the amphipod, *Gammarus* (Ståhl, 1938a, b).

In the stomatopods and the decapods the gland usually lies toward the dorsal side of the stalk, usually dorsal to a point between the medulla interna and medulla externa. Not uncommonly, however, it lies dorsal to the medulla interna as in the crabs, *Carcinus*, *Sesarma*, and *Aratus*. In still other species it lies even further proximally-dorsal to the region between the medulla interna and the medulla terminalis as in *Uca*, *Ocypode* and, *Pagurus*.

The decapod sinus gland is typically located in the wall of a dorso-lateral inner blood-sinus which is characteristically located between the medulla externa and interna. More specifically it is to be found in the region where this inner sinus opens into the large outer eyestalk sinus. In *Palaemonetes*, *Crago*, *Leander*, *Penaeus*, the inner sinus passing through the gland has a simple tubular form, thus yielding a beaker-shaped sinus gland with part of the gland still in association with the neurilemma proper and the remainder lining the inner blood-sinus near its point of entry into the large outer sinus.

In the deep-sea shrimp, *Acanthephyra*, and in such crabs as *Callinectes*, *Carcinus*, *Libinia*, *Ovalipes*, and *Cancer*, the gland has assumed a more or less globular form through becoming completely separated from the neurilemma and invaginated. The lumen of the gland retains its connections with both the inner and outer sinuses. The glandular products are discharged into the lumen. A still further step in the direction of complication of form of the gland is found in *Homarus*, *Astacus*, and *Cambarus* in which the inner sinus has become highly branched and the gland continues to line this branched structure. The gland thus assumes a highly complex form.

In the anomurans in which the gland is located in the head, it is probably secondarily simplified. In these instances it is in contact with a large outer blood-sinus but no inner one.

All of the sinus glands thus far examined in detail appear to possess the eosin, acid-fuchsin or light-green staining inclusions and all appear to have the fine secretory canals for conducting the product of the gland to the sinus. The sinus gland is always richly innervated. A large nerve innervating it is described by Hanström to arise in the medulla terminalis and to terminate over the inner surface of the gland. This innervation has been confirmed by Welsh (1941) who used a methylene blue technic. Welsh described a more complex innervation of the sinus gland of *Cambarus bartoni*. In this species a branch of the oculomotor nerve terminates in the region of the gland. Furthermore, the sinus gland nerve which can readily be traced into the gland tissue proper is seen to consist of some fibers arising in the medulla terminalis of the stalk and other fibers arising from the supraoesophageal ganglion of the head. If such a complex innervation should be demonstrated for crustaceans in general, it would appear that this gland is one of the most intricately innervated of endocrine glands.

A. Integumentary chromatophore control

1. The chromatophores, their pigments and activities

The endocrine activity of the eyestalks of crustaceans was first established through their relationship to physiological color changes. In the Crustacea, such color changes were first observed by Kroyer (1842) in the shrimp, *Hippolyte*, and seen to be due to the activity of integumentary chromatophores by Sars (1867). Crustacean chromatophores and their responses have since been the subjects of many investigations. The early literature has been very ably summed up in the extensive review of Fuchs (1914). For our present discussion, any detailed consideration of these earlier works is not in order. All these early investigators, largely on the basis of the classic work of Pouchet (1872, 1873, 1876) and the extensive studies of Gamble and Keeble (1900), and Keeble and Gamble (1900, 1903, 1904, 1905), were convinced of direct nervous control of the chromatophores and all of their observations were so interpreted. Investigations were primarily concerned with (a) the structure of the chromatophores, (b) the nature of the pigments, (c) the mechanism of movement of pigments within the chromatophores, (d) the embryological development of chromatophores, (e) the innervation of chromatophores, (f) relation of eyes to color change, (g) internal and external factors affecting the state of the chromatophores, and (h) the utility of these changes to the animal. We shall, however, have later a number of occasions to call attention to specific observations of certain of these early investigators as evidence for hormonal activities.

Between 1914 and 1925 little or no significant advance was made in the field of crustacean color physiology. Koller (1925) published the first paper giving evidence that chromatophores within this group of animals were hormonally controlled. There appeared thereafter a considerable number of investigations following up this suggestion. It is with these latter investigations that we shall be concerned primarily.

The chromatophores which have been most extensively investigated lie in the hypodermis or in the connective tissue just beneath it. In many crustaceans chromatophores are also located in association with the digestive tract, the central nervous system, the musculature, the blood vessels, or other internal organs.

For a number of years the view put forth by Pouchet (1876), that the chromatophores were ameboid cells capable of sending out pseudopodia among the surrounding cells, was the prevalent one. But, largely due to the excellent work of Keeble and Gamble (1904), Fröhlich (1910), Franz (1910), Degner (1912), and Perkins and Snook (1931), it is now generally held that the chromatophore is a multinucleate or multicellular body with permanent branching processes. Pigment may at one time concentrate into the chromatophore center, and at another time move centrifugally to fill the processes.

In and associated with the chromatophores are pigments of a number of different sorts. The kinds of pigments present in any given instance vary with the species and to a lesser extent with the individual. Not enough is known about these pigments to describe them in any detail chemically, but we can describe them generally in the following manner. Black or brownish-black pigment, in all probability a melanin, occurs in all the isopods and brachyuran decapods thus far carefully investigated. Such a pigment also occurs in the single macruran decapod, *Crago*, and probably also in the amphipod, *Hyperia*. Yellow, or red and yellow, fat-soluble pigments, apparently of a carotinoid nature, appear to be of quite general occurrence. A white pigment, which has been described as guanin, is almost universally found among the higher crustaceans. Finally there is a blue pigment which has been described by Verne (1923) as a carotinoid conjugated with a protein (carotin-albumine).

All these pigments are to be found within chromatophores, though one of them, the blue, is found commonly outside of chromatophores in the surrounding tissues.

The different pigments may be located within separate chromatophores (monochromatic) or there may be two or more pigments within the same one (polychromatic). In the latter instances, the pigments usually do not mix with one another and usually there are separate chromorhizae into which the pigments flow centrifugally. A notable exception to this last is seen in the case of the red and the intrachromatophoric blue pigment of many forms which are blended together to form commonly seen brownish-black, brownish-red, or purplish pigments of certain species.

A few higher crustaceans are either entirely without, or nearly without, colored chromato-

phores. This condition is found in a number of cave-dwelling or burrowing decapods and isopods. It is also seen in such exclusively nocturnal species as *Anchistioides*. Large numbers of other species show little or no response of their integumentary chromatophores to light and dark, or to background color. These latter include the large crabs, lobsters, crayfishes, etc. Certain others, as the fiddler crab, *Uca*, show relatively little response to background color but exhibit a definite, diurnally rhythmic color-change becoming pale at night and dark by day due to concentration and dispersion, respectively, of the dark pigments. This rhythm is partially independent of background or light intensity. Still other crustaceans, including such ones as *Hippolyte*, *Palaemonetes*, *Leander*, *Crago*, *Ligia*, *Portunus*, etc., show not only chromatophore responses to light and dark, but also a greater or lesser ability to mimic the shade or even the color of the background upon which they are placed in light. This last ability is seen in its highest state of development in *Palaemonetes* and *Hippolyte* in which all spectral colors may be more or less well matched (Gamble and Keeble, 1900; Minkiewicz, 1908; Brown, 1935a), and in *Crago* where only green and blue can not be matched as a result of the absence of a blue pigment within these animals (Koller, 1927).

In general, in those crustaceans able to adapt themselves to their background color the adaptation is attained by differential movements of the pigments in such a manner that the pigment, or pigments, essential for the particular adjustment move centrifugally in the chromatophore, while those which would operate against the particular adjustment move centripetally. A dispersed pigment tends to contribute its color to the macroscopic coloration of the animal while a concentrated one contributes little or nothing.

In addition to color change through migrations of existing pigments (physiological color change), there is an actual formation and destruction of pigments (morphological color change). Whereas physiological color change is usually a relatively rapid process occurring within an hour or two, morphological color change occurs much more slowly, requiring a matter of days (Keeble and Gamble, 1904; Koller, 1927; Brown, 1934) for significant changes to occur. Both processes proceed together to produce the complex color change adjustments seen in nature. There has been no research specifically directed at the control of morphological color change, but it has been observed (Keeble and Gamble, 1904; Brown, 1934) that a dispersed pigment gradually increases in quantity and a concentrated one decreases. If this is eventually shown to be generally true, then it would appear that the same mechanism shown to control physiological color change would also in all probability be found to control the morphological.

The compound eyes of the higher crustaceans are always essential to the normal responses of the chromatophores to backgrounds. The case is not so simple for the responses to light and darkness where it differs with the animal and also with the chromatophore type. The colored pigments of *Palaemonetes* and *Crago* on the one hand cease their responses to light and darkness after the compound eyes are removed, while comparable ones of Hippolyte continue to respond. The white chromatophores show similar variation although these tend in general to be less dependent upon the compound eyes than the dark and colored pigments. Thus far in the vast majority of instances it has not been determined whether the chromatophore responses of eyeless forms is the result of the direct action of light upon the color cells, or is an indirect one operating through other receptor mechanisms in conjunction with nervous and hormonal activities.

2. The eyestalks and chromatophore control

The first clear evidence that blood-borne substances were active in controlling crustacean chromatophores came from Koller (1925, 1927) working on *Crangon* (*Crago*) *vulgaris*. He found that when 1/10–1/40 cc. of blood was transfused from animals darkened upon a black background to ones blanched upon a white background, the latter animals distinctly darkened, the telson in 5 to 8 minutes and the whole body in 10 to 20 minutes, and remained darkened from 30 to 120 minutes. Comparable transfusions from white-adapted animals to black-adapted ones did not result in lightening of the latter. White-adapted animals remaining upon a white background became distinctly yellowish from five to ten hours after receiving a transfusion of blood from a yellow-adapted animal. The times of these changes following the transfusions were roughly comparable with the rate of color changes in response to black and yellow backgrounds.

In 1928 Perkins published the results of some extensive experiments on *Palaemonetes vulgaris*. He had searched in vain for nerve endings at the

chromatophores. The chromatophores would not respond to electrical stimulation as would typical nerve-controlled effectors, and no nerve transections interfered with the normal darkening and lightening of the body in response to backgrounds. Occlusion of the dorsal abdominal vessel, on the other hand, resulted in immediate cessation of color change posterior to the point of occlusion. When the obstruction to blood flow was removed, that part of the body posterior to the obstruction very quickly darkened if the rest of the body was dark, or lightened if the rest of the body was light. Perkins believed these latter observed effects were due to the backward flow of a "factor for expansion" or a "factor for contraction" of the red chromatophores as the specific case happened to be. He then proceeded to extract various organs of the body in sea water and to inject these extracts into other individuals. He discovered that a sea-water extract of eyestalks would produce a rapid paling of darkened animals and that extracts of no other organs of the body tested (muscle, liver, nervous organs, etc.) nor sea water alone could do so. He could find no organ extract which would result in a darkening when injected into the bodies of white-adapted shrimp. He concluded that the eyestalks contained sources of a hormonal substance which produced blanching of the body, i.e. contraction of the red and yellow chromatophores (and expansion of the white, Perkins and Snook, 1932). He also observed that eyestalks from white-adapted animals were many times as effective in this respect as eyestalks from black-adapted animals. An extract of the former maintained the red pigment contracted for as long as 24 hours, while a comparable extract of the latter maintained the red contracted only about a half hour. This degree of difference may be questioned in the light of later research in which in no case, regardless of strength of the extract, did the hormone maintain its activity for even nearly 24 hours.

In the same year Koller (1928), working primarily upon *Crago*, confirmed Perkins' conclusions that sea-water extracts of eyestalks from white-adapted animals contained a material highly effective in blanching shrimp, and went on to demonstrate quite conclusively that the material was neither species- nor genus-specific by reciprocal injections of extracts between species of *Leander*, *Processa*, and *Crago*. Koller gave the name *Weissorgan* to the yet undescribed eyestalk source and named its dark-pigment-concentrating principle "contractin."

Following upon these discoveries there was demonstration very quickly that aqueous extracts of eyestalks (in certain species, the head) of numerous crustaceans possessed a chromatophorotropically active substance. To date no less than 75 species of crustaceans including representatives of the Branchiopoda and all the major subdivisions of the Malacostraca have yielded positive results upon appropriate testing. These tests have consisted of injecting extracts into *Palaemonetes*, *Leander*, *Crago*, *Uca*, *Penaeus*, or other animals whose chromatophores were readily observable, and noting the effects. Very commonly the recipient was an individual whose eyestalks have been removed a day or so prior to the test. In these eyestalkless individuals the animal's own source of this hormonal material had been removed and the chromatophores were in a condition which was, at least in part, the result of its absence.

Only the isopods, *Oniscus*, *Porcellio*, and *Mesidothea*, of the crustaceans examined, appear not to possess such a chromatophorotropic principle (Ståhl, 1938a, b). However, the evidence suggesting its absence is by no means conclusive and would bear re-investigation.

a.) Red, brown, and black pigments.

The various dark chromatophore types to be found among crustaceans may respond in different ways to removal of the eyestalks (removal of compound eyes and a chromatophorotropic hormone source). Correspondingly the various chromatophore types may respond in different ways to injections of aqueous extracts of eyestalks. On the basis of our present information we can at least tentatively divide the crustaceans into three groups in respect to this behavior. In the first group would fall the great majority of macruran decapods, isopods, and Mysidacea. The second would contain the brachyuran decapods and certain isopods. In the third would be the genus *Crago*. Let us consider now the chromatophore-response characteristics of these three groups.

1.) Most of the macruran crustaceans resemble *Palaemonetes* in having a reddish or brownish pigment as their principal dark pigment. Regardless of its distribution within the chromatophores at the moment of eyestalk removal, it rapidly passes to a state of broad dispersion (resulting in darkening of the animal) and remains there indefinitely. This fact has been known since Pouchet's (1872–76) observations on *Palaemon* (*Leander*) and it has since been confirmed by numerous investigators for *Palaemon*, (Fröhlich, 1910; Megušar, 1912; Doflein,

1910; Bauer and Degner, 1913, etc.), *Palaemonetes* Megušar, 1912; Perkins, 1928; Brown, 1933, etc.), *Potamobius* (Megušar, 1912; Kalamus, 1938a), *Macrobrachium* (Smith, 1930), etc. Also showing this same type of response is *Macromysis* (Keeble and Gamble, 1904). As far as is known such eyestalkless animals no longer show a response of their dark pigments to backgrounds or to light and dark. Eyestalkless *Hippolyte varians*, however, are reported to show the dispersed condition of their dark pigment when in light and a concentrated condition in darkness, (Gamble and Keeble, 1900; Kleinholz and Welsh, 1937). The explanation of this continued chromatophore response is very much in doubt. The hypothesis of a direct effect of light on the chromatophores as advanced by Kleinholz and Welsh has not adequate supporting evidence as yet.

The response of these "*Palaemonetes-like*" eyestalkless crustaceans to extracts of eyestalks (or, in special cases, heads) of crustaceans is always a rapid concentration of the dark pigment and a consequent blanching of the animal (Perkins, 1928, etc.).

2.) All of the brachyuran crustaceans thus far investigated resemble the fiddler crab, *Uca*, in their response to eyestalk removal. They rapidly become and remain pale as a result of a lasting concentration of their black and red pigments (Megušar, 1912; Carlson, 1935, 1936; Abramowitz, 1935). This concentrated condition is usually maintained regardless of background or light intensity. However, eyestalkless *Uca* appear to show a slight diurnal rhythm with the chromatophore often showing a very slightly dispersed concondition (stellate) of the pigment during the day and a completely punctate condition at night. This rhythm may persist in constant light conditions.

The response of *Uca* to injections of eyestalk extracts is one of rapid dispersion of the dark pigment and consequent darkening of the animal (Carlson, 1936; Abramowitz, 1937a). Koller and Meyer (1930) found a similar response of the melanophores of *Idothea tricuspidata*; thus, the response of the dark chromatophores of "*Uca*-like" species to such experimental conditions is the reverse of that found in the "*Palaemonetes*-like" group.

3.) Thus far, the genus *Crago* (*Crangon*) seems to form a third group by itself, with respect to the behavior of its dark chromatophores following removal of the eyestalks. Upon eyestalk extirpation and sealing of the stubs by cautery to prevent bleeding there is a transitory darkening of the telson and uropods and a transitory lightening (under some circumstances, a darkening) of the remainder of the body (Brown, 1939a; Brown and Wulff, 1941). After an hour or so the animal assumes a mottled coloration due to the complete concentration of red and black pigments in telson and uropods, broad dispersion in certain other areas (to form a characteristic dark pattern), and intermediate degrees of dispersion over the remainder of the body, (Koller, 1930; Brown and Wulff, 1941). Although Kleinholz (1938) states that the dark pigment is found in an intermediate condition, his photograph (fig. 5) of an eyestalkless animal indicates his animals to show fully expanded and contracted melanophores as described by Koller and Brown and Wulff.

Thus far we have been dealing solely with the dominant, dark pigment of the crustaceans which largely dominates their adaptive responses to dark and light backgrounds. These pigments vary from red, through reddish-brown and sepia-brown, to black. The reds and reddish-browns are commonly lipochromes; the blacks and sepia-browns are usually melanins.

When all is considered, we see no strict relationship between the color, or chemical constitution, of the pigment and the nature of the response of its containing chromatophore to removal of the source of the eyestalk material or to injection of extract of eyestalks. We see melanin of *Uca* concentrating upon removal of eyestalks, and dispersing under the action of eyestalk extracts. On the other hand, melanin of certain isopods is concentrated under action of eyestalk extract. The melanophores of both these animals are even further similar in that both are monochromatic yet they respond in opposite fashion. In *Crago*, within the same individual, certain melanophores respond to eyestalk removal by concentration of the pigment, certain others by complete dispersion, and still others by assuming an intermediate condition; but all three types respond to an aqueous extract of *Crago* eyestalk by pigment concentration, thus in this respect act like the dark pigment of "*Palaemonetes*-like" species. That these different responses of the *Crago* black chromatophores are due to fundamentally different physiological characteristics of the chromatophores will become apparent later in this review.

b.) Yellow pigment.

The yellow pigment responds to eyestalk ampu-

tation in practically all crustaceans by pigment dispersal and to injection of extract of eyestalks by concentration (*Palaemonetes*—Perkins, 1928; Brown, 1933; *Uca*—Abramowitz, 1937b). In Crago the yellow responds a little differently, maintaining a state of intermediate dispersal after eyestalk removal (Koller, 1930; Brown and Wulff, 1941) and responding to injection of eyestalk extract by first concentrating strongly, and then dispersing strongly. Thus, there is not complete constancy of behavior of the yellow pigment of all crustaceans with respect to the eyestalk hormonal source.

c.) Blue pigment.

The blue pigment has been investigated far too little to attempt general remarks here. Observations of Brown (1935b) suggest that a hormone arising in the eyestalks controls its activity in Palameonetes.

d.) Reflecting-white pigment.

The state of the reflecting-white pigment of eyestalkless crustaceans has been variously described by different investigators even for the same species. For all crustaceans the condition appears definitely to be variable, with the limits ranging from complete dispersion to full concentration. There has similarly been much variation in the response of these chromatophores to injections of eyestalk extract: *Dispersion*: *Palaemonetes*—Perkins and Snook (1932); *Crago*—Koller (1930), Abramowitz (1937), Brown and Wulff (1941). *Concentration*: *Palaemonetes*—Brown (1935b), Hanström (1937a); *Leander*—Knowles (1939); *Uca*—Abramowitz (1937b). This great variability of the white chromatophores under these experimental conditions will probably later be traceable to (1) an extra-eyestalk source of the dominant hormone influencing this pigment (Brown, 1935b; Knowles, 1939; Brown and Wulff, 1941), (2) a direct response of these chromatophores to light intensity (Degner, 1912; Stephenson, 1932, 1934; Knowles, 1939; Brown, 1939c), or to (3) some combination of these.

Thus, in summary, the results of eyestalk-extirpation and of injection of extracts of eyestalks point to the definite conclusion that in the eyestalks are sources of a hormonal material normally influencing the integumentary chromatophores. The specific nature of the action of eyestalk hormonal material differs in different groups of crustaceans.

3. Localization of hormone source in eyestalks

The first published attempt to locate in the eyestalk the source of the pigment-contracting substance was by Koller (1930). Koller extracted the retinal portion of the eyestalks of *Crago* on the one hand, and the rest of the stalks on the other. The retinal extracts elicited a week reaction, the rest of the stalk a strong one. He concluded that the glandular source of the hormone must therefore lie distally in the stalk near the base of the retina. He believed that a blood-cell-forming gland which lay antero-dorsally in the stalk was responsible. His attempt at destruction of this gland by cautery resulted in a lasting darkening of the whole animal.

Hanström (1933) and in the following year Sjögren (1934) described a gland in the crustacean eyestalk which was first called the "blood-gland" and was believed to be homologous with Koller's "glood-gland." Later, Hanström (1937a) concluded that this gland could not possibly be homologous with the "blood-gland" and changed the name of the newly described gland to the "sinus gland." He concluded that Koller's "blood-gland" and Sjögren's "sack-formed organ" were homologous, and that this latter gland could not be the source of the chromatophore-activating principle since this organ was not present in the highly active eyestalks of *Palaemonetes* and certain other crustaceans. Furthermore, this gland was not innervated as one would expect the chromatophore-influencing gland to be.

The newly discovered "sinus gland," on the other hand, was found in every one of 25 or 30 malacostracan crustaceans which were examined (Sjögren, 1934; Hanström, 1937a; Ståhl, 1938a, b). It was in all instances a well-defined and richly innervated secretory organ judging from its histological picture. Hanström (1935, 1937a) conducted a long series of experiments involving a number of species of crustaceans to determine whether the sinus gland was the specific source of the chromatophore controlling substance from the eyestalks. These experiments, in brief, consisted of dividing the eyestalks of the various crustaceans into halves, thirds, or other fractions by transverse or diagonal sectioning, and then determining histologically the contents of the portions found to have chromatophoric activity upon injection into *Palaemonetes vulgaris*, *Uca pugilator*, or *Penaeus brasiliensis*. By means of these experiments, and the natural anatomical differences among crustacean species, Hanström was able to advance excellent evidence to support the conclusion that it was the sinus gland which was the source of the

material, and not another tissue or organ of the eyestalk.

In the first place, Hanström found that every section of the eyestalk which possessed any significant activity contained either the whole sinus gland or a part of it. In *Pagurus* eyestalk of which both the proximal and middle thirds of the stalk were active, the sinus gland was found to be an unusually attenuated organ extending through much of both of these thirds. In *Gebia* and *Hippa* whose eyestalks were quite without any activity, the sinus glands were not in the stalks but rather in the heads closely associated with the brain.

One by one Hanström eliminated the possibility of other normal eyestalk organs as sources of the material. First he considered the nervous elements of the typical stalk. The lamina ganglionaris was in almost every case in an inactive portion. The medulla externa was present in inactive fractions of *Homarus*, *Pagurus*, and *Uca* stalks, and was alone with the lamina ganglionaris in the entirely inactive stalks of *Hippa*. The medulla interna was the ganglion most usually extracted along with the sinus gland since the gland usually lay close to it. The distal third of *Uca* eyestalks, however, as a result of the somewhat unusual position of the ganglia, was inactive and yet this part contained the medulla interna. Also, in *Pagurus* where both proximal and middle thirds of the stalk were active, the medulla interna was present only in the middle third. The medulla terminalis was similarly excluded by its being present in inactive portions of the stalks of *Homarus*, almost wholly present in the inactive proximal third of *Palaemonetes* stalks, and absent from the more effective middle third of *Pagurus* stalks.

The X-organ was another probable (see Part III) endocrine source in the eyestalk. Hanström used, in excluding this gland as the source of the particular hormonal material in question, the argument that he was unable to demonstrate this gland histologically in the chromatophorically active stalks of *Cambarus*, *Astacus*, *Sesarma*, and *Aratus*, and in *Uca* this gland was either very poorly developed or absent. This argument must be treated with some reservation inasmuch as this is negative evidence. It is interesting that Welsh (1941) has called attention to an organ in the eyestalk of *Cambarus* which from its location and innervation is probably the X-organ. Better evidence for the elimination of the X-organ as the gland in question came from Hanström's localization experiments. Although in almost every instance the X-organ and the sinus gland were in the same fraction of the stalk (or in special cases the head), yet in the more effective third of the stalk of *Pagurus* and in the active smaller distal "half" of *Callinectes* stalk, the X-organ was absent. It was present, however, in the active proximal portions of these stalks, which contain in each case also a fraction of the sinus gland. Two more special experiments were performed by Hanström in his attempt to eliminate the X-organ. First, he was able to section the head of *Hippa* in such a manner as to contain the X-organ but not the sinus gland. This fraction was inactive upon chromatophores. Second, with an electric cautery he destroyed the sinus gland region of one eyestalk of *Callinectes*, leaving the other eye intact. He believed this operation left the X-organ on the opposite side of the stalk uninjured. A few days later an extract of the intact eye was fully active; that of the operated eye, inactive.

Hanström ruled out other organs of the eye such as the eyestalk muscles and the hypodermis since they were commonly in inactive portions of the stalk; indeed they comprised the major portion of the inactive stalk contents of *Gebia*.

These excellent and extensive experiments of Hanström based upon this comparative study of a large number of crustaceans rendered the fact of chromatophoric activity of the sinus gland very highly probable. It was still possible that the source was a tissue which was usually closely associated in position with the sinus gland. Furthermore, most of Hanström's localization experiments were performed using only the red chromatophores of *Palaemonetes vulgaris* or *Penaeus brasiliensis*. In only one or two cases were *Uca* black chromatophores used. Hanström himself admitted the possibility that another organ in the eyestalk might secrete some chromatophorotropic substance. Final and complete demonstration could come only by extirpation of the gland by itself and assaying extracts of it or by implanting it into sinus-glandless individuals.

A step in the direction of the final resolution of this problem was made when Brown and Cunningham (1939), in connection with their work on the hormonal control of molting, discovered that the sinus gland in living *Cambarus* was readily distinguishable from the remainder of the eyestalk contents by bluish-white opalescence when viewed by reflected light. In fact, once one is familiar with the gland one can readily find it with his unaided eye, although it is near the limit of visibility in medium-sized crayfish. This gland was shown

to be easily removable with the aid of needle-pointed jeweler's forceps.

Brown (1940) dissected out the sinus gland from the eyestalks of seven species of crustaceans (*Carcinus*, *Callinectes*, *Uca*, *Libinia*, *Pagurus*, *Crago*, *Palaemonetes*), extracted them and then compared the activity of these extracts with the activities of extracts of the remainders of the stalks and of other whole stalks of equal size. The red chromatophores of *Palaemonetes* and the black ones of *Uca* were used simultaneously in the assays. It was found that the sinus gland by itself though normally comprising about 1/100 the volume of the soft tissue of the stalk possessed about 80 per cent of the chromatophoric activity. The remaining 20 per cent of the activity was readily explainable in terms of diffusion of the material from the gland into other eyestalk tissues and from minute fragments of the gland not removed. In fact, while dissecting out the gland it was not uncommon to see a bluish cloud diffusing away from the gland into the surrounding tissues. Judging from the relative effects upon the two chromatophore types used, the qualitative effects of the glands by themselves were quite similar to those of the eyestalks minus the glands; thus if there was a second source of chromatophorotropic material in the stalks, the second source produced a substance with a physiologically similar action on these two chromatophores.

Further evidence for the action of the sinus gland came from its implantation into the ventral abdominal sinus of eyestalkless *Palaemonetes*. Such implants maintained the red pigment concentrated for several days, the length of time the implants remain viable judging from their appearance through the highly transparent ventral body wall. No extract of eyestalk, on the other hand, even though containing the material of as much as 60–100 eyestalks per c.c. will maintain such pigment concentrated for more than a few hours.

The exoskeleton of *Palaemonetes* is so highly transparent that with proper lighting the gland can be observed readily in the living animals. Brown, Ederstrom, and Scudamore (1939) were able to remove the sinus gland from the eyestalks of *Palaemonetes* with a micro-aspirator. Such sinus-glandless animals, although behaving as animals with vision, showed a complete dispersal of their red pigment regardless of color of background. Sacrificed animals of this type possessed eyestalks whose extracts showed little or no chromatophoric activity.

Brown and Ederstrom (1940) and Brown and Wulff (1941) added all the eight chromatophore types of *Crago* to those which are definitely activated by an extract of sinus glands.

It thus appears to be true beyond doubt that the sinus gland is the source of the hormonal material which blanches darkened shrimp through concentration of their red and yellow pigments (brown and black melanoid pigment, in addition, in *Crago*), and which darkens pale *Uca* through dispersion of its black and red pigments.

Whereas whole eyestalk extract has been variously described as concentrating or dispersing white pigment, in all cases where sinus glands alone have been extracted, the extracts invariably have dispersed white pigment (*Cambarus*–Brown and Meglitsch, 1940; *Crago*—Brown and Wulff, 1941; *Uca*—unpublished observation).

4. Number of chromatophorotropic principles in the eyestalk

Crustaceans in general, it has been seen, contain from three to five differently colored pigments in their chromatophores. The responses of these pigments to a change from a black to a white background and vice-cersa have been observed by nearly every investigator of crustacean color-change physiology. To these backgrounds the various pigments respond, within the limits of rather wide individual variation, in a manner characteristic for the species. It has, furthermore, been observed that as far as the dominant dark and colored pigments (and to some extent, the others) are concerned, the animal responds to an injection of eyestalk extract in much the same fashion as to an illuminated white background (Abramowitz, 1937b). Thus, removal of the eyestalks results in a darkening of *Palaemonetes* and similar forms and injection of eyestalk extract blanches them (Perkins, 1928). Removal of eyestalks from *Uca* results in a paling of the animal as during the nocturnal phase and injection of eyestalk extract results in a darkening as during the diurnal phase of their color change (Carlson, 1936).

Abramowitz (1937b) assembled a considerable body of information upon the comparative effects of extracts of eyestalk of one species upon the chromatophores of others. In addition he added many reciprocal injection experiments using *Palaemonetes*, *Crago*, and two species of *Uca*.

Abramowitz observed that, as far as he could determine, the effect of injection of eyestalk extract of the other three species into a certain species was the same as that resulting from the injection of extract of eyestalks from animals of the same species. His data were rather incomplete. But on the basis of these rough qualitative experiments he concluded that all crustaceans produced in their eyestalks, or in special cases in the head, a single hormone which was common to them all. This hormone was called the eyestalk hormone and was abbreviated to E. S. H. (Abramowitz and Abramowitz, 1938). Abramowitz believed that all the differences between species in the responses of their chromatophore complexes to the hormone were explainable in terms of specific differences of the end-organs.

Relatively few investigators have studied in any detail the relative behavior of the various pigment types of an animal in response either to black and white backgrounds, or to colored ones. All who have, have been impressed with the two phases of color adjustment. The initial phase is a movement of the pigments upon change from a white to a colored background in much the same manner as in the response to change from a white to a black background; conversely a change from a black to a colored background starts usually as in a change from a black to a white one. After a time ranging from a few minutes to a few hours the various pigments commence differential movements in responses to the specific colors. In brief, the immediate response to color appears to resemble either the effects of injection of eyestalk extract, or the removal of the eyestalks with their included gland.

The ultimate responses with respect to background colors are usually quite different from that to be expected from the operation of a single principle. Keeble and Gamble (1900) state that in color adaptations the four pigments of *Hippolyte* "are distributed independently of one another in the sense that one pigment may become aggregated in the center of the 'chromatophore' whilst another runs out into its network of processes. Change of colour appears to be due to a fresh pigmentary deal of the shuffled colour pack." Such a pigment independence in *Hippolyte* in response to colored backgrounds was confirmed by Minkiewicz (1908). In 1927, Koller working with *Crangon* (*Crago*) *vulgaris* observed that color adaptation to red and to yellow backgrounds involved independence of the red and yellow pigments with respect to one another and to the brownish-black pigment. Koller established the separate hormonal nature of the control of the yellow pigment by finding that blood from a yellow animal transfused into a white one brought on a yellowing of the latter. On the basis of Koller's (1928) and Perkins' (1928) results Parker (1930) also concluded several hormones must be involved.

The general matter was confirmed and extended by Brown, (1933, 1934, 1935a, b) who observed that the four pigments found within *Palaemonetes* showed relatively independent behavior in the responses to various backgrounds. Considering the pigments in all possible combinations of two he noted that in each case the first pigment could be concentrated while the second was either concentrated or dispersed, or the first could be dispersed while the second was in either state. He demonstrated that this relative independence of the pigments persisted in a region which had been denervated, thus showing that this complex behavior of the four pigments was solely under hormonal control. Brown concluded that four hormones must be operating to account for this independence. However, Parker (1940) has properly called attention, since, to the possibility of three being adequate to account for this behavior.

A comparable independence of certain pigments of *Portunus* was demonstrated by Abramowitz (1935). Since eyestalk-extirpation and eyestalk-injection experiments had given good evidence that a substance from the stalks had definite influence upon the red, yellow, and blue pigments, Brown (1935b) concluded that the eyestalk must contain several hormones, one primarily influencing each of these pigments. This conclusion was not justified. All that was proven by this work was that somewhere in the body of the crustacean were principles bringing the total to a minimum of three. An equally reasonable assumption would have been that modifiers of the effects of a single eyestalk principle were produced at another locus or other loci in the body. At any rate it was evident that several hormones were involved. Interesting in this connection is the belief of Koller (1928) that the gland producing the *Gelbstoff* was separate from both the eyestalk *Weissorgan* and the rostral-region *Schwarzorgan*.

More recently Carstam (1942) has presented evidence favoring the hypothesis of separate hor-

mones concentrating the red and yellow pigments of *Leander*.

Despite the striking relative independence of activity of pigments of *Hippolyte*, *Crangon*, *Palaemonetes*, and *Portunus*, Abramowitz (1937b) believed that the various background responses of the chromatophore complex of an individual animal were explainable solely in terms of specific differences of the various chromatophores in their type and threshold of responses. He neglected, however, to explain how such could possibly account for the relative independence of four pigments in a single animal in the light of the many injection experiments indicating only a single threshold of any one pigment to eyestalk extract. Despite this, the "unitary hypothesis" (involving a single hormone) of chromatophore control was still considered a possibility by Hanström (1938a) and Kleinholz (1938, 1942).

In 1940 Brown and Scudamore attempted to resolve the question as to whether a single, or more than one, hormone was produced in the eyestalks and sinus glands. They reasoned that if a single hormone was present in all crustacean eyestalks, then the relative effects of all stalk extracts upon two widely different chromatophore types, *Uca* black and *Palaemonetes* red, would be similar. They tested the eyestalks of *Crago*, *Carcinus*, *Libinia*, *Uca*, *Pagurus*, *Callinectes* and *Palaemonetes* and found that the ratio $\frac{\text{effect upon } Uca \text{ black}}{\text{effect upon } Palaemonetes \text{ red}}$ varied in a regular and repeatable manner with the species source. At one extreme was *Crago* with a great effect upon *Uca* black and a relatively small one upon *Palaemonetes* red, and at the other extreme was *Palaemonetes* whose stalk extracts were relatively much more effective upon its own red chromatophores. Between *Crago* and *Palaemonetes* came in order of size of the ratio, *Carcinus* > *Libinia* > *Uca* > *Pagurus* > *Callinectes*. This order followed neither the sizes of the animals from which the eyestalks or glands were removed (which were in grams, 1; 60; 50; 2; 11; 100; 1) nor the relative potencies of the extracts as assayed for these animals upon *Uca* black chromatophores by Abramowitz (1937a) (which were in *Uca* units; 0.25; 1.25; 4.0; 1.0; 1.25; —; 0.36).

Although these results were highly suggestive, the quantitative aspects of the data for certain species (*Callinectes*, *Libinia*, and *Carcinus*), though roughly adequate, were not sufficiently accurate to base definite conclusions. But, largely on the basis of the results with the remaining species, Brown and Scudamore set up the hypothesis that in the stalks of all the species were two chromatophorotropic principles with the various species differing in the ratio of quantities of the two. This appeared simpler than a hypothesis that each species possessed its own characteristic hormone showing different relative effectiveness upon the two chromatophore types. The hypothesis of the two active principles was thoroughly confirmed by briefly extracting dried eyestalks or sinus glands of each species in turn with 100 per cent ethyl alcohol and later with sea water. In every species the "alcohol-soluble" fraction had a relatively strong effect upon *Palaemonetes* red and a very weak effect upon *Uca* black. The residue after alcohol extraction had an equivalent or weaker effect upon *Palaemonetes* red, but a very strong action upon *Uca* black. In all cases the "alcohol-soluble" fraction showed a significantly lower ratio, $\frac{\text{effect on } Uca \text{ black}}{\text{effect on } Palaemonetes \text{ red}}$, and the "alcohol-insoluble" fraction a distinctly higher ratio, than whole eyestalk extract. The original ratio could be obtained again by mixing the two fractions. It thus appeared well established that sea-water extracts of crustacean eyestalks or sinus glands contain at least two principles.

That the presence of two principles in eyestalks and sinus glands of crustaceans does not complete the picture of number of principles is seen in the observations of Brown and Ederstrom (1940). These investigators found that sea-water extracts of the eyestalks or sinus glands of *Crago*, and to a lesser extent *Palaemonetes*, possess a principle which concentrates the red and black pigment in the telson and uropods of *Crago*, while comparable eyestalk and sinus gland extracts of *Carcinus*, and in all probability also *Uca* and *Libinia*, do not possess this property. Brown and Wulff (1941) showed this latter principle to be present only in the "alcohol-insoluble" fraction of *Crago* eyestalks, although the "alcohol-soluble" fraction contracted strongly the other dark pigment of the body. There appears to be no likelihood that these differences between crustacean eyestalks in the possession of a *Crago* "tail"-lightening principle are explainable in terms of only two principles uniformly occurring in the stalks of all crustaceans.

It thus appears beyond little doubt that, considering crustaceans as a group, at least three differ-

ent chromatophorotropic substances are to be found within the sinus glands. The data at hand do not permit one to differentiate between two possibilities: (1) *Crago* and *Palaemonetes* possess three principles; the other crustaceans tested, two; (2) all crustaceans possess two principles, one of these two being chemically different in *Crago* and *Palaemonetes* from that in the other crustaceans tested.

5. Properties of chromatophorotropic principles of the sinus gland

Almost all of the studies which have been made upon the properties of the chromatophore-affecting substances of the eyestalks have been done with the assumption that a single principle is involved. This viewpoint is quite untenable for it is readily demonstrable that eyestalk extracts may be resolved into two or more physiologically different chromatophore - activating components. This resolution has been accomplished through differential solubilities and by comparing activities of sinus glands from different species (Brown and Scudamore, 1940; Brown and Wulff, 1941). The adherents of the single-hormone hypothesis could well be asked which of these components, if any, they consider to be normal "chromatophorotropic hormone." Thus, in speaking of the properties of a chromatophore-activating hormone we must make clear what we are discussing. This may be done in terms of the particular end organ or organs upon which the assays were made. But even these conclusions are not entirely safe since it is very probable that different chromatophorotropic hormones have overlapping effects upon the different chromatophore types.

Very early, Perkins (1928) and Koller (1928) observed that sea-water extracts of eyestalks of white-adapted, *Palaemonetes*, *Crago*, and *Leander* were very effective in blanching dark animals of these species. Hence, the materials involved were readily water-soluble. Both Perkins and Koller agreed completely that the eyestalks of white-adapted animals were far more effective than those taken from black-adapted animals. These extracts were unboiled. Later Koller (1930) reported that the body-blanching hormone of the eyestalks of *Crago* would withstand boiling. This was confirmed by Perkins and Snook (1931) for *Palaemonetes*. The latter investigators reported great increase in effectiveness as a result of boiling their extracts. This was confirmed for *Cambarus* by Hanström (1937a) but denied for *Callinectes* and *Carcinus* by Hanström, and by Brown and Scudamore, (1940). This increase in effectiveness Perkins and Snook attributed to the more thorough extraction of the boiled tissues. Most of the subsequent works with macruran eyestalk hormones have dealt with boiled extracts, and the investigators have used, randomly, extracts from the stalks of black- or white-adapted animals since there seemed to be no perceptible difference in their activity. This similarity was confirmed quantitatively for *Palaemonetes* by Abramowitz (1937a) who apparently also used boiled and filtered extracts. The interpretation of his results was, however, further complicated by the usage of *Uca* melanophores for assay of activity.

If the above observations suggesting the eradication of a difference between the effectiveness of extracts of black- and white-adapted *Palaemonetes* through boiling are correct then certainly some chemical change is wrought by the temperature elevation, probably in the direction of reducing the sinus gland contents to certain relatively heat-stable chemical materials. Whether these include normal hormone molecules or merely active fragments of them remains a question. At all events the boiled extracts of all crustaceans show roughly similar properties with certain species and group differences (see part 4) which are explicable only in terms of quantitative differences in two or more components or in some more complex fashion. Investigators have hitherto, in general, taken it for granted that no change in the hormone results from heating. This matter deserves more attention.

Carlson (1936) was the first to attempt to determine chemical properties of eyestalk extract. He found that active material would diffuse readily through a cellophane membrane, thus being of relatively low molecular weight. Furthermore, this material, though soluble in alcohol, was insoluble in ether. The stability of the material was such that it could be boiled for a few minutes in dilute HCl or NaOH without losing its effectiveness.

Abramowitz (1936a, 1937a, 1938, 1940) in a series of papers, described in further detail the properties of the eyestalk extract using *Uca* black chromatophores for assay purposes. He confirmed the work of Carlson in large measure. He found that the material which he was assaying was "not completely soluble in ethanol or methanol," was

"only slightly soluble in acetone," and was "insoluble in organic solvents such as benzin, chloroform, or ether." It is not quite clear what was meant in describing "the eyestalk hormone" as not completely soluble in ethanol or methanol. This last becomes comprehensible only in terms of more than one active principle in the eyestalks.

Abramowitz also described in detail his attempt to purify "the eyestalk hormone" in which he started with a dry powder of total eyestalks of *Uca* having a potency of 0.6 *Uca* units per mg. After removing fatty material with petroleum ether, extracting with distilled water, boiling and filtering to remove the chitin, protein, etc., and washing further the dried residue with chloroform to remove lipochromes, the material was extracted with 95 per cent alcohol. It was finally extracted in absolute alcohol from which it was precipitated by ether. The resulting dried residue still showed an activity of only two *Uca* units per mg. The loss in total activity was about 60 per cent.

Probably a large part of the reason for the practical failure of Abramowitz to purify the principle influencing the black pigment of *Uca* is to be found in the observations of Brown and Scudamore (1940) indicating that the component of eyestalk extract *most* effective on *Uca* black is relatively insoluble in absolute ethyl alcohol.

Still using *Uca* black chromatophores for assay Abramowitz found, by extracting equal quantities of dried, partially purified, eyestalk material, in similar manners with a number of different solvents, that the following percentages of the activities went into solution.

Absolute ethyl alcohol	45
Absolute methyl alcohol	60
95 per cent ethyl alcohol	60
Absolute acetone	0
Ethyl ether	0
Petroleum ether	1
Benzene	1
Chloroform	0
Ethyl acetate	0
Pyridine	6
95 per cent acetone	2
90 per cent acetone	20
95 per cent methyl alcohol	80

Abramowitz further learned that boiling in 1 per cent NaOH inactivated the material in two hours, but similar boiling in HCl appeared to increase the activity of the material.

Abramowitz (1940)[1] employing adsorption technics finally succeeded in purifying the material to 100–200 times its original strength. The active material was found to react in a fashion characteristic for amino bases.

Perkins and Snook (1931) reported that desiccated eyestalks would retain their activity for long periods of time. This was confirmed by Hanström (1937a).

Abramowitz (1936a, 1936b, and 1938), determined the action of crustacean eyestalk extract upon fish, amphibian, and reptilian melanophores and the action of intermedin upon *Uca* melanophores. In the light of this information and the very closely similar solubilities of the two materials in a variety of solvents, he concluded that the crustacean eyestalk extract was very similar to intermedin. However, a number of facts indicate that they are not identical. For example, Abramowitz himself (1938) was unable to balance comparable doses for the vertebrate and *Uca*, nor was he able to demonstrate any significant influence of intermedin on *Palaemonetes* red pigment. Hanström (1937b) had similarly found no significant action of intermedin on *Leander* red pigment. Böttger, (1934) had observed that intermedin dispersed *Crago* black pigment, which was the reverse of the action of eyestalk extract. Thus, although there are a number of similarities between intermedin and crustacean eyestalk extract there is reason for believing that no substance identical with intermedin is to be found in the latter. Furthermore, it would appear that the eyestalk principle most closely resembling intermedin was that one having a particularly strong action on *Uca* black pigment.

Hanström (1937a, 1937b, 1938b) reported that in examining the tissues of *Loligo*, insects and arachnids for a substance similar to eyestalk extract in its chromatophorotropic properties, he had found definite activity of the heads of the orthopterans, *Melanoplus*, *Dissosteira*, *Trimeropteris*, *Dixippus*, *Chorthippus*, *Tettigonia*, and *Diapheromera*. Head extracts of the hymenopterans, *Psithyrus* and *Apis*, the coleopteran, *Coccinella*, and the dipteran, *Musca*, also yielded distinct responses. No such activity was found in the heads of the odonatan, *Sympetrum*, nor the lepidopteran, *Vanessa*. In an attempt to localize in the head the source of this crustacean chromatophore activator, Hanström sectioned the head of *Dixippus* into anterior and posterior halves. Only the latter were effective. Because

of their histological picture, Hanström suspected the corpora cardiaca or corpora allata which lay in the posterior half of the head of the activity. Brown and Meglitsch (1940) dissected out and extracted separately various organs in the head of the cockroach, *Periplaneta*, and found that extracts of the corpora cardiaca were six times as effective (volume for volume) in concentrating crayfish red pigment as were crayfish sinus glands. The corpora allata were inactive. Brown and C. M. Suter (unpublished) have found that the insect and crustacean materials are similar in their stability to boiling in weak HCl solutions, but are dissimilar in their reaction in NaOH solution at 100°C. In the latter, crayfish sinus-gland extract is first made slightly more effective, but after a short interval is rapidly destroyed while insect corpora- cardiaca-extract is destroyed rapidly from the beginning. This has been tentatively interpreted as due to the conversion of an inactive precursor into an active substance in the sinus-gland extract, and to the absence of such a precursor in the insect gland. A physiological difference suggested by Hanström (1938b) and entirely confirmed by Brown and Meglitsch is that whereas the sinus-gland extract activates white pigment, the insect corpora-cardiaca-extract does not.

Such experiments as the preceding have shown that although other groups of animals, both vertebrate and invertebrate, possess tissues yielding extracts having a roughly similar effect to crustacean sinus-gland extract, yet they are in all likelihood not identical. The similarity of action is in all probability due to close similarity in the molecular structure of the substances.

6. Control of hormone liberation

We cannot discuss with any assurance the control of hormone production and liberation by the sinus gland since we are not yet certain what are its chromatophorotropic principles and what are their specific actions.

All work in this direction that has been done has concerned only the liberation of a principle which acts upon the dark and colored pigments in the same manner as eyestalk extract injections. It is evident that such material is liberated into the blood of normal animals either under direct control of the compound eyes of the animal or in response to another mechanism having a 24-hour rhythm the cause of which is still unknown. Evidence for direct control by the compound eyes is seen in the cessation of all background or light and darkness responses of most crustaceans after the eyes have been opaqued or the retinas destroyed. Some crustaceans in this condition continue to exhibit responses to light and darkness to the customary extent (*Hippolyte*—Gamble and Keeble, 1900; Kleinholz and Welsh, 1937) or to lesser extents (*Ligia*—Smith, 1938). These responses have been attributed, without sufficient evidence, to the chromatophores acting as independent effectors.

Let us examine briefly the relation of the compound eyes to sinus gland activity. Keeble and Gamble (1904) believed the response of the chromatophores to background was a response to the ratio, incident light/reflected light, striking the eyes. Background studies and opaquing particular portions of the retina (Hanström, 1937a, 1938a) demonstrate that when the dorsal portion of the retina is stimulated and ventral portion non-stimulated or only weakly so, hormone liberation is more or less inhibited. When, on the other hand, the dorsal and ventral halves are equally stimulated, material is liberated, though apparently less so (Brown, 1935a) in darkness than in light. If the ventral portion of the retina, alone, is stimulated by light there is likewise secretion from the sinus gland.

On the basis of careful assays of the effectiveness of extracts of *Palaemonetes* eyestalks, under various conditions of backgrounds and in darkness, Abramowitz (1937a) concluded that stimulation of the dorsal half of the retina resulted in stimulation of hormone synthesis in the sinus gland. Stimulation of the ventral half of the retina resulted in a liberation of hormone from the gland and at the same time accelerated synthesis to compensate for that liberated.

Smith (1938) on the basis of very ingenious experiments with *Ligia*, concluded that stimulation of the dorsal portion of the retina resulted in the formation and liberation of a B (body-darkening) principle, and stimulation of the lateral and ventral portions of the retina resulted in the formation and liberation of a W (body-lightening) principle.

When the eyestalks bearing both the compound eyes and the sinus glands have been removed the chromatophores assume a state which is usually different from that following opaquing the retina, though also usually constant regardless of background or light intensity. The difference in the chromatophore state between the two conditions

(putting only the retina out of function, and removing the whole stalks) has been attributed by most workers either by statement or implication solely to the effects of removal of the eyestalk gland. If this were true then the sinus glands of retina-less *Palaemonetes*, *Leander* and most other macruran decapods would appear to continue to secrete the body-blanching hormone after the removal of the principal receptors normally involved since the dark pigment remains nearly completely concentrated. On the other hand, the homologous glands of isopods and of *Crago* would appear to be partially or totally inhibited under quite comparable conditions, since their dark chromatophores may have fully dispersed pigment. It is thus difficult or impossible to draw a generalization tion that the innervation of the sinus gland is solely inhibitory or excitatory.

Definitely in *Crago*, and in good probability in other crustaceans as well, other and frequently antagonistically acting glands are operating within the body, thus rendering questionable any interpretation we might make at this time regarding the nature of the control of secretion. It is not a simple matter to determine in an intact animal just what gland or glands are functional in producing any given pigmentary conditions.

Similar difficulties immediately become evident in attempting to determine to what extent the sinus gland is concerned with diurnally rhythmic color changes as in *Uca* (Abramowitz, 1937a), *Ligia* (Kleinholz, 1938), and *Leander* (Hanström, 1937b). The assumption has often been made that this rhythm in the chromatophores is induced solely by rhythmic secretion of the sinus gland. The discussion has largely centered around what the ultimate source of the rhythm in the animal might be. It is interesting to note here that Abramowitz (1937a) was unable to discover any significant difference in the potency of eyestalks of *Uca* in the day and the night phases. Furthermore, it might be pointed out that a rhythmic color change occurs to some extent in eyestalkless *Uca*, indicating beyond doubt that another source of a chromatophore-activating hormone is operating to produce the rhythm. Furthermore, it indicates definitely that the ultimate source of the rhythm in the animal is to be found in a tissue of the body outside of the eyestalks.

(To be concluded)

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to B. H. Willier, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, Homewood Campus, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

BRIEF NOTICES

EVOLUTION

MAN'S UNKNOWN ANCESTORS. *The Story of Prehistoric Man.*

By Raymond W. Murray. The Bruce Publishing Company, Milwaukee. $4.25. 9⅛ x 6⅛; xiv + 384; 1943.

Our knowledge of early man has been very significantly advanced by the many new discoveries of the last two decades. Books on prehistory of twenty years ago are already out-of-date and retain merely historical interest. The present volume fills the need for a comprehensive, up-to-date, popular account of man's rise from the time of the earliest human fossils to the dawn of that recent period in which man recorded his doings for posterity. Murray, head of the Department of Sociology at the University of Notre Dame, is thoroughly familiar with the widely scattered, technical literature on human palaeontology and archaeology which he has ably collected and "translated" for the layman in a conservative and reliable "story of prehistoric man" and of the very beginnings of civilization, taking into consideration all new evidence, unearthed in recent years.

In the opening chapter of the book it is pointed out that prehistory is a very young science and that for a long time the *Book of Genesis* had sufficed in dealing with all problems relating to man's past. Indeed, it is amazing that today we are able to plot the traces of man and his work on a time-scale that extends back for many hundred thousands of years, while barely three centuries ago the Vice-Chancellor of Cambridge University (John Lightfoot) had maintained seriously that man was created in 4004 B.C. on the 23rd of October at 9 A.M.

The introductory chapters discuss also the manifold modern techniques of prehistory and outline the salient conditions of the earth's history before the advent of man. The second and third parts of the book are devoted to the skeletal remains and the cultures of prehistoric man in the Old World. Here one might have expected, for general orientation, a much more adequate discussion of man's simian relations than are contained in the all too few remarks of the author. The latter include some erroneous claims, such as the untenable statement that the thumbs of apes are not opposable.

The fourth part of this volume describes the prehistorical discoveries in the New World in considerably more detail than has been given to the archaeology of Europe and Asia. This inconsistency and lack of balance, though excusable, is apt to give the lay reader the vague impression that the leading rôle in man's past was played on the American stage, even though it was shown that the human drama had opened incomparably earlier in the Old World. The European part of the story of man contains so many more scenes than the part of the Western Hemisphere that the former deserves much more space than the latter.

The final, fifth part, bears the title "Repercussions of prehistory". Here the author develops "his opinion on the alleged science-religion conflict . . . which the reader is free to take or leave." It must suffice to state here that this final, brief essay is frank, fair and interesting, but remains rather superficial.

The volume ends with a "Selected reading list" of nearly 100 titles and with a detailed Glossary.

This work deserves a wide distribution. The war has rendered it unlikely that the subject matter will again be significantly changed in the near future through the addition of great new discoveries.

THE IRISH STONE AGE. *Its Chronology, Development and Relationships.*

By Hallam L. Movius. The Macmillan Company, New York; Cambridge, at the University Press. $7.50. 9¾ x 7⅞; xxiv + 339 + 7 plates; 1942.

The Harvard Irish Survey devoted five years to the study of the broad problem of the origin and develop-

ment of the races and cultures of Ireland with the viewpoints and methods of physical anthropology, social anthropology and archaeology. The present volume is a report on the archaeological work of this ambitious research program. The introductory part of the book deals with the chronology of the late-glacial and early post-glacial periods in northern and western Europe with its varied related problems in climatology, palaeobotany, glaciology, etc. The larger, second part describes and discusses the stone age cultures of Ireland including the results from the author's excavations of six fruitful sites.

At the close of the late-glacial period in Britain man followed the retreating ice sheets northward, reaching Ireland with the opening of the post-glacial period during the beginning of the seventh millenium B.C. These first Irishmen were the descendants of upper palaeolithic hunters. A partial land bridge across the Irish Sea facilitated their immigration into a country with an abundant supply of flint for their simple tools. From a pure hunting stage the early settlers gradually changed to a general food gathering economy and, sooner or later, they must have learned to grow crops. The author traces and analyzes the slow development of culture in Stone Age Ireland on the basis of all accumulated archaeological evidence. The material culture is studied particularly in terms of the natural environment to which it had been adapted.

An impressive bibliography adds to the value of this comprehensive report on the origins of Irish civilization. The book forms a much needed and thorough contribution to European prehistory.

TERTIARY PRAIRIE GRASSES AND OTHER HERBS FROM THE HIGH PLAINS. *Geological Society of America Special Papers, No. 41.*

By Maxim K. Elias. Geological Society of America, New York. $1.50. 9¾ x 6¼; 176 + 15 plates; 1942 (paper).

The paleontology of the eastern slopes of the Rocky Mountains has, in the recent past, revealed convincing evidence that the tertiary fauna and flora of that region maintained qualities compatible with prairie life.

Since 1884, when the first systematic collections of fossil flora from the "High Plains" were made, many valuable materials have been accumulated, but it has been only within the past decade that any attempt has been made to describe or categorize these important finds. The present volume presents a description of the fossil grasses and related herbs from this area together with an evaluation of their affinities for their nearest contemporary relatives, *Stipeae* and *Paniceae*. The evolutionary trends of these two tribes of plants has been greatly clarified by this study.

The enormous amount of field work in collecting the materials, and the painstaking detail required for studying and describing the various forms are ample indications of the scope and value of this compendium of significant and fascinating facts.

The work is documented by a bibliography of some 145 titles, and carries 16 plates of illustrations. An index and a stratographic map showing the evolution of prairie herbs conclude the volume.

GENETICS

MEDICO-LEGAL BLOOD GROUP DETERMINATION: *Theory, Technique, Practice.*

By David Harley. Grune and Stratton, New York. $3.50. 8½ x 5½; ix + 119; 1943.

This book makes available in one small volume the necessary information concerning theory and technique for those who may be called upon to make blood group determinations for medico-legal purposes. The section on theory fairly completely, though briefly, outlines the A-B-O and M-N systems of blood types and their inheritance, and the theory behind the use of these blood groups in medico-legal practice is given. Under technique, the methods employed by the author and his coworkers for both fresh blood and blood and secretion stains are given in great detail with warnings of some of the difficulties often met. The final section entitled "Practice" discusses the legal position of tests for disputed paternity in England and gives a detailed description of fifteen of the author's cases in which blood and secretion stains were used.

The first two sections, while not pretending to be exhaustive, give an excellently clear and concise discussion for those who wish to use blood grouping in medico-legal work. The last section while of considerable interest to all may not be of great practical value to workers outside England. There is a list of references and both an author and a subject index.

GENERAL BIOLOGY

THE BIOTIC PROVINCES OF NORTH AMERICA.

By Lee R. Dice. University of Michigan Press, Ann Arbor. $1.75. 10 x 6¾; viii + 78; 1943.

This work represents an experiment in the classification and delimitation of the major ecologic areas of North America. It is based to a considerable extent upon the author's own observations, but the work of others has been used and an extensive literature is cited.

Each biotic province is characterized by peculiarities of vegetation type, ecological climax, flora, fauna, climate, physiography, and soil. However, because the data on plant distributions are more complete, plant associations were used in delimiting the boundaries of the provinces. Subordinate to the biotic provinces are biotic districts, which are based upon ecologic

differences of less importance than those which separate the provinces; and life belts, which are vertical subdivisions of a biotic province. A biotic province is characterized usually by a single climax association, but there may be two or more climaxes within a province as, for example, in mountainous areas, where each life belt may have its own climax.

A description of each biotic province is given, but information concerning Southern Mexico is meager since few ecological studies have been conducted in that region.

The information given in this work should interest geographers, ecologists, and all others who are concerned with the distribution of faunas and floras.

HUMAN BIOLOGY

SOCIOCULTURAL CAUSALITY, SPACE, TIME. *A Study of Referential Principles of Sociology and Social Science. By Pitirim A. Sorokin. Duke University Press, Durham, North Carolina.* $3.50. 9 x 6; ix + 246; 1943.

It is difficult to appraise this book. In it the author attempts to revivify a philosophy that was popular in the seventeenth and eighteenth centuries—that a dichotomy of the universe into the antitheses man and nature is not only possible and desirable, but that it is inevitable.

Here is a distinction without a difference. While such a dichotomization may, in some instances, be convenient there is no reason ever to consider it fundamental. Its convenience issues from the fact that man is at the same time the observing subject and the observed object. Certainly no such contrast would be noticed by an archangel, or one of Orson Wells' inhabitants of Mars, or the insects in Mark Twain's facetious sketch.

The author's argument is that sub-human biology is purely a physico-chemical science. The activities of all vegetable and animal life except man himself are physico-chemical reactions—a belief strongly reminiscent of the automatism of La Mettrie. But human biology, especially the social sciences, is an altogether different matter. Consequently the author begins his dissertation with a declaration of independence—the independence of the social sciences (which he calls the sociocultural sciences) of physical and chemical laws. The reader is likely to feel that this procedure does not accomplish so much the exaltation of the human as the degradation of the sub-human.

Of course no one would deny that the biology of human beings is far more complex than that of the lower animals, but the author maintains that the difference between the two biologies is qualitative as well as quantitative, and that the qualitative difference is best exemplified by the conceptions of causality, space, and time required in the two instances. Consequently, his book consists of five chapters, of which the first and last are introduction and conclusion, while in the remaining three, the nature of causality, space, and time, are taken up in decreasing order of complexity.

For the sociocultural sciences the classical space of three dimensions is entirely inadequate. But so is the multidimensional space of Lobachevsky and Riemann, for notwithstanding the fact that their geometries admit the conception of a curved space embedded in a matrix of higher order, the supernumerary dimensions which they introduce are of the same nature as the original three. They increase the complexity of the universe without increasing its profundity. A new kind of dimension is needed, and the author finds it in the cosmogony of Minkowski, which units space and time in a single continuum. But to reduce space and time to a common denominator for purposes of mensuration necessitates the use of imaginary quantities and thus expands the mathematical domain.

But in the sociocultural sciences time does not have the simplicity of meaning which it has in Galilean and Newtonian physics. Instead, it resembles that of the modern relativity theory, which, while it is monodimensional for any specific observer, in the general case does not run in the same direction for any two observers. To express the unit of time measurement for any one observer in terms of that of another observer involves a transformation of coordinate axes.

No one would dispute the author's right to appropriate for the sociocultural sciences the space-time continuum of relativity physics, but his tacit assumption that the antithesis between the sociocultural and physico-chemical sciences can be accounted for on the ground that they employ different conceptions of space and time is seriously open to question. After all, the relativity theory and the conception of a space-time continuum belong to the physico-chemical sciences in which they originated, and their adoption by the sociocultural sciences serves only to strengthen the tie that binds all the sciences into one perfect theoretic and philosophic whole. As is so often the case, the author seems to be right in what he affirms and wrong in what he denies.

RACE: SCIENCES AND POLITICS. *Revised Edition. By Ruth Benedict. The Viking Press, New York.* $2.50. 7¾ x 5; xi + 273; 1943.

In a decade torn with strife and culminating in a world-wide contest of the force of arms, Ruth Benedict discusses a philosophy which has done much to create strife and may well prevent mankind from constructing a better world when the war is over. Racism, the doctrine which attempts to classify the races of man on the basis of superiority and inferiority—whatever these two terms may mean—has existed in one form or

another from the days of Ancient Rome to those of the Third Reich. Indeed, all primitive peoples naively think that they belong to an elect group. Only in the modern world, however, has racism become a psychological cancer which now endangers international peace and cooperation for perhaps centuries to come. Racism has become a political weapon by means of which unscrupulous leaders can divert the attention of their insecure and anxious followers to a tangible scapegoat and away from themselves.

Race is a biological fact which lends itself to scientific study. Racism is a way of thinking, based upon a myth—the myth that it is possible to classify objectively the races of man according to worth—whatever the criteria for this may be. Miss Benedict convincingly shows that such attempts lead to rather ridiculous results and that no one race has a monopoly of hereditarily desirable characteristics.

In order to understand race persecution, one must investigate not race, but persecution. Persecution was an ancient story before racism was thought of. Inevitably social change is fought by those whose ties are to the old order. Those who have such ties will manage, consciously or unconsciously, to ferret out reasons why their group is extremely valuable and why its loss would mean the death knell of civilization. In order to maintain the old order as long as possible, they will turn the forces aroused by discontent upon an easily delimited minority group, be it religious, political, or racial. So, in the last analysis, racism can be reduced to just another form of persecution of minorities for the advantage of those in power.

Racism is at present one of civilization's most destructive forces. It can be combated only by remedying major social abuses—in short, only by making members of all races equal before the law; by placing no tacit restrictions on the Bill of Rights and the Constitution.

Miss Benedict's book is clearly and forcefully written. It is elementary anthropology integrated with an analysis of the causes of human conflict. It deserves to be read and promulgated by all who claim an interest in human progress.

CHIEF SEATTLE.

By Eva Greenslit Anderson. The Caxton Printers, Caldwell, Idaho. $4.00. 9 x 5¾; 390; 1943.

This is the "biographie romancée" of Sealth, a Squamish chief of Puget Sound, after whom Seattle was called at its founding in 1853. Sealth's life (1785–1866) fell into the fateful period from the discovery of his homeland (through Vancouver in 1792) to the final victory of the white settlers over the Indians in the war of 1856, a victory that was largely due to the political attitude taken by Sealth. Early baptized by Catholic missionaries, he was a devoted friend of the whites (therefore his tribe, as usual, suffered particularly harsh treatment from the invaders). Divided in his loyalty between white and red men, Sealth was driven into great inner conflicts. Their description is one of the best parts of Mrs. Anderson's book. Sealth undoubtedly is of great local importance for Seattle and the State of Washington, and Mrs. Anderson has done her best to make this red Quisling sympathetic to the reader. As for the reviewer, he feels more interested in men like the rebellious Leschi who is only casually mentioned by Mrs. Anderson.

The book is based on a study of the source-material. Numerous footnotes and an extensive bibliography prove the painstaking research of the author. But the success of a "biographie romancée"—this strange mixture of science and art, nowadays so fashionable—depends mainly on the ability of the writer to grasp the psychology of the personality with whom he deals. It is particularly difficult for a white author to revive the mentality of primitives. That it can be done to a certain degree is shown by such books as the Eskimo novels of Peter Freuchen or René Maran's "Batouala." Mrs. Anderson has not succeeded in her undertaking. To be sure, her characters "potlatch" and headhunt and speak a rather exasperating baby-talk which, by also including numerous native words, probably is meant to recreate the atmosphere in which the Northwest Indians lived. But all figures remain red painted white phantoms as they are found in those silly books on Indians which are given into the hands of our children. The many illustrations, I am sorry to add, are on the same level.

ALASKA: AMERICA'S CONTINENTAL FRONTIER OUTPOST. *Smithsonian Institution War Background Studies Number Thirteen. (Publication 3733.)*

By Ernest P. Walker. Smithsonian Institution, Washington, D. C. Free. 9⅛ x 6⅛; iv + 57 + 21 plates; 1943 (paper).

Contrary to general belief, Alaska is not a forbidding, inhospitable region. It has wide diversity of topography and climate, and much of the Territory is unsurpassed in beauty of scenery and as a recreational area. Newcomers, says the author of this timely text, rarely like Alaska at first, but if they stay as long as a year, they almost invariably become enthusiastic about the country and have no desire to leave. He believes that the sense of untrammeled freedom, coupled with the unsurpassed scenery, the great friendliness of the people, and the general atmosphere of genuineness form the basis for a fascination that few can resist. It seems that the white population of Alaska is decidedly cosmopolitan, in that every region of the United States is represented, and many foreign countries. In spite of the fact that the population is very sparse and that the Territory is still considered a frontier, modern con-

veniences are enjoyed in a surprisingly large proportion of the homes. This reviewer was somewhat amazed to learn that the average standard of living of Alaskans is actually higher than that of the average resident of the States, and that in the present stage of development of the Territory, extremes of poverty and opulence are lacking. A great deal has been written and said regarding the future of Alaska, particularly with relation to an increase in the population. The present author feels that even though this never takes place on the scale that some advocate, Alaska can nevertheless continue to prosper through development in a field in which no other part of the world is a close competitor.

In order, the author discusses the following features of our "treasureland of the North": strategic importance, geography, topography and climate, native peoples, history, natural resources, and development. The booklet is profusely illustrated with maps, tables, and a number of beautiful photographs which add greatly to the reader's enjoyment. There is a bibliography, but no index. This illuminating report is highly recommended to the average reader who wants to know more about the world in which he lives.

ICELAND AND GREENLAND. *Smithsonian Institution War Background Studies Number Fifteen. (Publication 3735.)*

By Austin H. Clark. Smithsonian Institution, Washington, D. C. Free. 9⅛ x 6⅛; iv + 103 + 21 plates; 1943 (paper).

With the modern development of the submarine, the airplane, and the radio, Iceland and Greenland have become of great importance to all military operations in the North Atlantic area. These two regions, near together and very similar in some ways, are quite dissimilar in other ways. Iceland, Europe's westernmost outpost, was uninhabited when first discovered. It was peopled by immigration chiefly from Norway, and soon developed into a unified nation which has to a large extent retained its original characteristics but little changed by what has happened in the rest of the world. From Iceland the countries of Europe, and from them our own country, derived the parliamentary system of government. From the extensive and varied early literature of Iceland we learn much of what we know of the history of Europe in the early days and of ancient Scandinavian mythology, and all that we know of the early colonization of Greenland and of the attempted colonization of Vinland (North America).

Greenland, the easternmost outpost of America, at the time of its successful colonization, was inhabited by Eskimo. It is a trade colony with a sparse population of Europeans and about forty times as many natives. As a Danish colony it has been closed to foreign trade and other influences. Every possible effort has apparently been made to develop the region for the benefit of the native peoples, to create among them a national democratic feeling, to develop a national literature and culture, and to guard them from harmful contacts. It may be noted in passing that at the present time the product of the cryolite mine at Ivigtût, which is the largest in the world, is of great importance to us in the war effort. The native Greenlanders are of much interest to us, for in the early days of Danish colonization they did not differ greatly from the Eskimo in Alaska.

The sections on modern Iceland and Greenland are especially interesting. Several maps and a series of exceptionally fine photographs do an excellent job of illustrating this timely, extremely interesting and very instructive little book. There is a selected bibliography, but no index.

ISLANDS AND PEOPLES OF THE INDIES. *Smithsonian Institution War Background Studies Number Fourteen. (Publication 3734.)*

By Raymond Kennedy. Smithsonian Institution, Washington, D. C. Free. 9¼ x 6½; iv + 66 + 21 plates; 1943 (paper).

Between Australia and the Philippine Islands lies the largest archipelago in the world, the East Indies. It stretches for some 3000 miles along the equator from just south of the Malay peninsula eastward to the Solomon Islands. Now in the hands of the Japanese, it serves as one of the outer defenses of the recently expanded Japanese Empire. It also affords the conquerors much that they need for a balanced, self-sufficient economy—rich natural resources, fertile soil, uninhabited land, and a large native population in need of industrial goods. It is a prize of battle that they will be reluctant to forfeit.

To those interested in following the development of the war in the southwest Pacific, the present War Background Study of the Smithsonian Institute is highly recommended. By reading the twenty-nine topics discussed in this small volume, one can acquire a wealth of information on all phases of life in the East Indies. Such topics as the geography, climate, diseases, animal life, travel and transportation develop a very clear picture of the type of battle fields and obstacles confronting the military forces.

The native population is quite heterogenous with regard to racial stocks and temperaments. It ranges from the small, sedate Malays to the tall, aggressive Papuans. The former are generally remarkably friendly and polite to strangers, while the latter may be unfriendly or openly hostile. However, it should be added as stated by the author "among about 90 per cent of the Indonesian peoples, one encounters an easy graciousness and charm of manner unsurpassed anywhere else in the world." This is comforting to know

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in anticipation of the number of our aviators who may have to parachute to safety over these islands.

The book is interestingly written and beautifully illustrated with numerous photographs. There are several maps outlining the general topography of the islands and the distribution of the various racial groups. There is no index but a well organized table of contents.

ARCHAEOLOGICAL RECONNAISSANCE IN CAMPECHE, QUINTANA ROO, AND PETEN. *Carnegie Institution of Washington Publication 543.*

By Karl Ruppert and John H. Denison, Jr. Carnegie Institution of Washington, Washington, D. C. $4.75 (cloth); $4.25 (paper); 11½ x 9; vii + 156 + 75 plates; 1943.

This is an account of four expeditions made since 1932 into Southern Yucatan, the Mexican province of Campeche and the Guatamalian province of Peten. Twenty-nine abandoned Maya cities were explored, many of them for the first time. No excavations were made and it is quite possible that mounds and jungle may still hide many other sites.

Ruppert first gives a short technical report of the expeditions in this difficult terrain and then summarizes the findings: the farther south the sites are located, the more they are related to the courtyard arrangement of the Uaxactum *E* type, which may have an astronomic or ritualistic significance. Two architectural types can be clearly distinguished—in the south, the Peten type with indentation of the façade and in the north, the Rio Bec-Chene type with towers. In the north, including Rio Bec, the lowermost sections of the buildings are elaborately decorated. The architecture in the south seems to the author to be a temple-type; that in the north, a palace-type. Data on stelae cover various extensions of time, those in Naachtun encompass 260 years. From the data on the stelae the authors conclude a gradual northward spread of the stela cult. A detailed description of the ruins by Ruppert and of the monuments by Denison follows, and a wealth of most excellent illustrative material (maps, plans, reconstructions, photographs) completes the volume.

CULTURE ELEMENT DISTRIBUTIONS: XXIV. *Central Sierra. Anthropological Records, Volume 8, Number 4.*

By B. W. Aginsky. University of California Press, Berkeley. 75 cents. 11 x 8½; 393–468 + 1 map; 1943 (paper).

This is another of the *Culture Element Distributions* studies of the University of California. Aginsky has checked 2324 traits in nine Miwok, two Yokut and two Mono localities of the Central Sierras. He gives some very useful complementary ethnographic notes on the element list, and an equally enlightening short "discussion" of the method of his inquiry.

ZOÖLOGY

THE AMNICOLIDAE OF MICHIGAN: *Distribution, Ecology, and Taxonomy. Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 57.*

By Elmer G. Berry. University of Michigan Press, Ann Arbor. 85 cents. 10 x 6¾; 68 + 9 plates + 10 maps; 1943.

The Amnicolidae are a family of small aquatic snails of world-wide distribution. Although the habitats of the individual species are quite circumscribed, the family as a whole is ubiquitous in its distribution. One species has been taken in snow fields at an altitude of 11,000 feet, another from a depth of 1,000 feet or more in an artesian well, and another from the alkaline incrustations of a Death Valley sink nearly 200 feet below sea level. Although generally found in fresh water, one genus is exclusively marine.

Geologically the family seems to be of unusual age (for a fresh-water family) for it has developed some peculiar genera in those two most ancient bodies of fresh water, Lakes Baikal and Tanganyika, as well as in the relict lakes of the Lahontan and Cahuilla basins.

During the last half-century many of the species and genera included within this family have been removed on the ground that they exhibit certain modifications of structure that seem to testify against the homogeneity of the group, and as further investigation of comparative anatomy is made it is likely that the family will be reduced still further. In this work the author has segregated the genus *Pomatiopsis* in a new family based upon differences in dentition. This is doubtless a wise step, for the peculiar geometrid method of locomotion combined with the equally peculiar habit of forsaking its aquatic environment in favor of a terrestrial one hints at a certain amount of taxonomic isolation, but it must be confessed that on the whole the morphological differences are not nearly so pronounced as the habitudinal ones, and that the need for dismemberment of this family would not be acutely felt had it not included such a diversity of habitats.

GENERAL CATALOGUE OF THE HEMIPTERA. *Fascicle IV, Fulgoroidea. Part 3. Araeopidae (Delphacidae).*

By Z. P. Metcalf. Smith College, Northampton, Mass. $5.00. 9 x 6; 552; 1943 (paper).

This volume is Part 3 of Fascicle IV, being the sixth publication in a series that will eventually comprise all the members of the order Hemiptera. Fascicle I included the Membracidae; II, the Mesoveliidae; III, the Pyrrhocoridae; IV, the Fulgoroidea. Of the latter

super-family, Parts 1 and 2 consisted of the Families Tettigometridae and Cixiidae respectively, while Part 3, the present issue, covers the family Araeopidae, better known but incorrectly so, as Delphacidae.

Each family is treated by a specialist in his respective group. In a work as monumental as this one, it would be impractical, if not well nigh impossible, to analyze individually each described species as to its validity as a taxonomic unit. Therefore recourse has been made to published reviews and opinions rendered by others; in cases not so covered the species are listed for future revisers. Under the family, sub-family, genus, species, and variety names there are listed chronologically all references that have been made in the literature under those headings up to the year 1940. After each citation a short note is appended which suggests the nature of the data contained therein.

The careful and painstaking labor that has gone into the preparation of this volume has resulted in an authentic, accurate, and invaluable contribution to entomology. There is still much ground to cover; it is to be hoped that the completion is not far off. With such a handy reference, the synonymy caused by the description of already recognized forms should be cut to a minimum and the laborious "search through the literature" will be facilitated. The conservative price of this work is remarkable considering the amount of labor and research that went into its production.

HERE COME THE ELEPHANTS.

By Gertrude Orr. The Caxton Printers, Ltd., Caldwell, Idaho. $2.50. 9 x 6; 208; 1943.

The first live elephant reached this country in 1796. Ever since the largest of our land mammals has been a never failing, popular attraction in circuses and zoos. In view of this widespread public interest in elephants the present volume can expect a ready sale. It is an entertainingly written story of elephant life in captivity from birth to death, with occasional digressions giving brief accounts of the elephant's rôle in ancient warfare, at the courts of oriental potentates, of the capture of wild elephants, their employment in commercial enterprises, etc.

The author presents a full-sized, popular picture of elephantine behavior. Incidentally, it shows some of man's folly in dealing with his colossal slave. It tells of a Mexican promoter who insisted on matching several bulls against a circus elephant (the astonished bulls were sent crashing through the arena gates) and of a well-meaning driver who tried and failed to stop a stampeding elephant by blocking the street with his roadster. Of facts from "behind the scenes" it reveals that in Hollywood they hang rubber ears and celluloid tusks on Indian elephants for African jungle pictures. In the circus' beauty parlor elephants have their skin rejuvenated with oil from spray-guns, their nails polished with huge files, and their hair removed with blow torches before they enter the ring to stand on their heads.

To the zoologist this volume is of interest chiefly on account of its many and unusual photographs. Unfortunately, most of these are rather poorly reproduced.

BEEKEEPING *for Profit and Pleasure.*

By Addison Webb. Illustrated by Natalie Harlen Davis. The Macmillan Company, New York. $2.00. 9⅞ x 7¼; 116; 1943.

This attractive and concise volume written by an experienced apiarist contains a wealth of useful information on bee-culture. Description of the various types of individuals, queen, workers, and drones, which make up the colony and their behavior is limited to the essentials necessary for recognizing them and their activities. Most of the book, therefore, is concerned with topics such as hive location and construction and management during the various seasons, as well as where and how to obtain bees, how to install them properly in a hive, etc. Attention, of course, is given to the important matter of disease and enemies and various control measures. The reader is referred to certain free and helpful circulars issued by the U. S. Department of Agriculture.

Timely suggestions in the form of recipes are included for substituting honey for rationed sugar and butter. The closing chapter provides a list of "honey plants" with a schedule showing their distribution in typical sections of the U. S. and their season for nectar and pollen production.

The exceptionally effective illustrations consisting of nine double-page spreads of line drawings are most helpful in showing exactly how to do things. The illustrated chapter heads are particularly attractive and appropriate. The volume is indexed.

LABORATORY EXPLORATIONS IN GENERAL ZOOLOGY.

By Karl A. Stiles. The Macmillan Company, New York. $2.50. 11 x 8¼; x + 265; 1943 (paper).

Out of the author's many years of classroom and laboratory teaching in the field of general zoology has come this excellent laboratory manual. The general plan of the work follows the "type" method of presentation, though the structure and content provide a wide variety of teaching methods and laboratory procedures. The "explorations" cover an orderly sequence of organisms from the protozoa to the frog, and may be used in conjunction with any standard zoology text.

Each lesson includes a detailed description of the form under consideration, careful instructions for the dissection, study, and drawing of the external and

internal anatomy, and a variety of demonstrations, questions and problems designed to clarify the physiological, embryological, and evolutionary processes of the organism. Special emphasis is placed upon the scientific method of investigation, and a sound knowledge of the principle involved is essential for the completion of each problem. The outline drawings provide for a minimum of artistic skill and mechanical work, and for a maximum of time for dissection, study and experimentation.

A list of some 140 books on general zoology and related subjects is included.

COMMON INSECT PESTS OF STORED FOOD PRODUCTS. *A Guide to Their Identification. British Museum (Natural History) Economic Series No. 15.*

By H. E. Hinton and A. Steven Corbet. British Museum (Natural History), London. 1s. 8½ x 5½; 44; 1943 (paper).

This booklet is concerned with the identification of insects and arachnids commonly found in domestic food stores or a ship's cargo. The material is presented in simplified form, only the most elementary technical terms being used. The species are arranged systematically by orders. A brief general description is given of each order, followed, whenever necessary, by keys of families and species. The distinguishing characteristics listed are only those which can be seen either with the naked eye or a hand lens. Many excellent diagrams assist in an interpretation of the keys. This simplification of the material makes the booklet extremely useful to the layman, who, after identifying a particular pest, can then proceed intelligently to obtain information concerning the treatment for its eradication.

While the pamphlet is written especially to meet the problem of food storage for the English—it belongs in that extremely well-planned "Economic Series" issued by the Natural History division of the British Museum—the same pests are a problem to mankind over a large part of the world.

DENTITIONAL PHENOMENA IN COBRAS AND OTHER ELAPIDS WITH NOTES ON ADAPTIVE MODIFICATIONS OF FANGS. *Bulletin of the American Museum of Natural History, Vol. LXXXI, Art. III.*

By Charles Mitchell Bogert. The American Museum of Natural History, New York. 9¼ x 6¼; 285–360 + 3 plates; 1943 (paper).

Consequent to a comparative study of tooth succession, structure, and function in cobras, the author has first to review the taxonomy of the group, which is admittedly based on too few specimens for final conclusions. Reasons are advanced for nomenclatural retention of the family Elapidae. Similarities in the venom apparatus suggest that the living Elapidae, Hydrophiidae, Viperidae, and Crotalidae are all descended from a single terrestrial elapid progenitor. The mechanism of fang replacement is described. Cobras that are known to spit their venom possess modifications of the discharge orifice which serve to direct the venom forward instead of downward. The phylogeny and zoogeography of the various species are fully discussed. There are 73 excellent figures, several maps and plates and a complete bibliography in this thorough and critical study.

THE BIRDS OF SOUTHERN VERACRUZ, MEXICO. *Proceedings of the United States National Museum, Volume 93 (Number 3164).*

By Alexander Wetmore. Smithsonian Institution, Washington, D. C. 9½ x 6½; 215–340; 1943 (paper).

The present account relates to the birds in the Canton of the Tuxtlas, in southern Vera Cruz, and is based on collections and studies made in 1939 and 1940, with additional observations made in nearby localities. The list covers 291 forms of birds that were certainly identified. Notes of interest relative to the abundance, behavior, and other biological data accompany the majority of forms listed. Pertinent and critical taxonomic comments are made for certain forms, as *Colymbus dominicus, Centurus aurifrons*, and others.

A detailed itinerary and a description of the physiography of the region precedes the annotation. Most of the area covered lies in the humid division of the Tropical Life Zone. Across the higher section of Cerro de Tuxtla and Volcan San Martin there is a small area belonging with the Subtropical Zone; it contains 16 characteristic forms, five of them being endemic.

THE GRASSHOPPER BOOK.

By Wilfrid S. Bronson. Harcourt, Brace and Company, New York. $1.75. 8½ x 6; 127; 1943.

The author says that he had always felt that Aesop's ancient fable about the noble ant and the worthless grasshopper was most unfair.

We admire the ant for working hard and being thrifty. Why not admire the grasshopper for being independent and self-reliant? The main task of both is to keep their kind from perishing from the earth, as it is with all creatures, including ourselves. . . . Men, ants and grasshoppers preserve their kind, each in his own special way. Since each succeeds age after age, why should one be praised more than the other?

In this most captivating little book the author writes about the "truly wonderful ways" and "special equipment" of the grasshoppers and their remarkable relatives, the katydids, crickets, roaches, walking-sticks

and praying mantises. The text is abundantly illustrated with the author's own skillful and accurate drawings.

EOCENE FORAMINIFERA FROM THE TYPE LODO FORMATION, FRESNO COUNTY, CALIFORNIA. *Stanford University Publications, University Series, Geological Sciences, Volume III, Number 3.*

By Lois Martin. Stanford University Press, Stanford P.O. 75 cents. 10 x 7; 35 + 5 plates; 1943 (paper).

The microfauna from the type Lodo formation includes at least 173 species. Thirty are new species and two are new sub-species which are described and illustrated herein. The remainder are listed in tabular form, each accompanied by its stratigraphic range within the Lodo formation. The fauna is composed of genera which in modern seas appear to favor temperate waters.

BOTANY

PLANTS AND VITAMINS.

By W. H. Schopfer. Translated by Norbert L. Noecker. Foreword by W. J. Robbins. Chronica Botanica Company, Waltham, Massachusetts; G. E. Stechert and Company, New York. $4.75. 10¼ x 6¾; xiv + 293; 1943.

This is a notable, significant book, highly important to Biology and most timely in its appearance, reflecting great credit on Noecker for his translation and on Verdoorn for the excellent management which made possible the appearance of this valuable volume in English at this time. As the author, in this field which has shown such striking development into general significance in recent years, was not only one of the pioneer workers but has been one of the most able, frequent, and outstanding contributors, the book is authoritative, analytical, and comprehensive. The point of view is that of the general physiologist; the objective, the presentation of the significance of vitamins in the physiology of plants and animals.

It is effectively organized in three parts; (1) the synthesis of vitamins in the auxo-autotrophic plants capable of such synthesis; (2) the relation of vitamins to the auxo-heterotrophic plants incapable of such synthesis; and (3) some of the general aspects of vitamins in their relation to the soil and agriculture, to sexuality, to such methods of life as symbiosis and parasitism, with significant analysis of some of the problems involved.

Although dealing primarily with the rapid development of our knowledge of vitamins and the part they play, and exactingly detailed and informative on their biochemical and biological aspects, the book is in no sense theoretical or academic, but highly practical in pointing out the applications of this knowledge of the action of vitamins in horticulture, nutrition, agriculture, industry, and medicine. Here the investigator will find the fundamental basis for some of the most important phenomena in biology with sound points of departure for the interpretation of others that are still baffling and obscure. It is the most complete and valuable book in the field that has yet appeared, worthy of much more extensive and commendatory review than the space allotted here permits. It is throughout exceedingly stimulating and inevitably will lead to a rapid increase in work in the field, for here are outlined or implied many significant problems that clamor for solution. One cannot read the book without a growing feeling of admiration for the work that has been done, the problems that have been solved, and the steady progress that has been made in this field—one of the most difficult yet fascinating in biology. One reaches the last chapter thoroughly convinced of the soundness of the author's conclusions that vitamins are essential factors for growth and potent regulators of metabolism, that lack of vitamins results in severe and frequently disastrous disturbances, and that the fundamental functions of vitamins are alike in plants and animals although the final expression may differ.

Although known to most of us for his outstanding work, the author here reveals himself as a man readily appreciative of excellence in the work of others in the field, and grateful for the help of associates and students, the translator, editor, and others who have aided the preparation of the book. His apologies for omissions that may have occurred, because he has been on active service much of the time since 1940, show his conscientiousness, although in matter of fact most of the important work of 1941–1942 has been included. No one can read this book without feeling admiration for the author as an outstanding and productive scientist and as a man, nor fail to sorrow with him that his final question—why is it that skillful men from different nations can solve problems in fundamental biology but cannot solve the national problems which directly concern themselves—remains unanswered.

AN INTRODUCTION TO INDUSTRIAL MYCOLOGY. *Second Edition.*

By George Smith. Foreword by Harold Raistrick. Longmans, Green and Company, New York; Edward Arnold Company, London. $6.00. 8¾ x 5½; xii + 260; 1942.

This second edition of this valuable book, in addition to all the fundamental material of the first edition, includes an expansion of the previous briefer treatment of the yeasts into a more extensive and effective chapter. Also, there is a new key to the Hyphomycetales follow-

ing the more modern concepts of E. W. Mason, and hence simpler and more valuable to beginners in Mycology than the classical and more abstruse keys of Saccardo. The commendable objective of the first edition is attained here also. Presentation of fundamental, detailed, accurate knowledge of moulds, their structure and reproduction, their response to environment, their biochemical characteristics, for the benefit of those, chiefly chemists and chemical engineers, who will be using moulds as microbiological agents in productive industries—this objective the book attains with notable success.

The book begins with chapters on the general characteristics of fungi and of the groups in which the moulds occur, with explanations of the fundamental principles of classification and nomenclature and terminology. Seven detailed chapters follow on such groups of moulds as the Zygomycetous Mucorales, the Ascomycetes, the Fungi Imperfecti, and the yeasts and related forms, with especially detailed treatment of the exceedingly important Hyphomycetales and a separate chapter on each of the two outstanding genera, *Aspergillus* and *Penicillium*.

The last third of the book has very valuable chapters on the necessary equipment and technique for culturing, isolating, and studying moulds, another on the maintenance of the culture collections that are essential to industries that make use of moulds, followed by a very helpful chapter on the physiology of moulds, another of great practical value on the control of mould growth, and a final one pointing out some of the chief categories of uses of fungi in industry. The book terminates with an exposition of the mycological literature useful to the industrial mycologist or chemist, pointing out the chief monographs on particular genera, noting the pertinent books on general mycology, and especially emphasizing the books, journals, and periodicals devoted to industrial mycology. A helpful index with subjects, genera, species, authors, and other items, extensive and usable, makes it easy for the reader readily to find any item sought.

There are few, if any, technical errors, the only one catching the eye of this reviewer being the attributing of the discovery of Bordeaux mixture to Pasteur rather than to Millardet.

One of the most valuable features of the book is the inclusion of 136 excellent photomicrographs whose fine half-tone brings out the structural details most effectively. Some of these by Smith have already appeared in technical and mycological journals, and this second edition contains about a dozen new illustrations. The plan of having these figures face the relevant text has been followed successfully even though the paper shortage has made necessary printing these plates on both sides of the paper. A few of these illustrations are not too successful. Figure 7, a sporangium of *Rhizopus nigricans*, shows little detail that would be of value to the student, and wastes some space since, as a single small figure on the back, it occupies but a part of the space of the plate. Similarly, there is some waste of space through keeping Figure 34, of ascospore production in Saccharomyces, in its position relevant to the text, for it too occupies but a small part of the full-page plate. All of the figures are valuable as illustrations, most of them of notable technical excellence in presenting important structural features, and a few are truly beautiful in themselves. Figure 113, of the conidiophores of *Penicillium Charlesii*, for example, in composition, balance, and tone would make an impressive decorative print.

THE BOLETACEAE OF NORTH CAROLINA.

By William Chambers Coker and Alma Holland Beers. University of North Carolina Press, Chapel Hill. $7.00. 10 x 6¾; viii + 96 + 65 plates; 1943.

Although primarily a technical monograph of the small but interesting family of fleshy mushrooms which bear their spores on the lining of tubes on the under side of the cap, this volume is of more general interest, for in addition to presenting the characteristics essential to the identification of these forms by means of technical descriptions and numerous excellent illustrations, it also takes up their edibility, notes the few dangerous species such as those of the *B. miniato-olivaceous* complex and those such as *B. Satanas* and its allies of the suspect *luridus* group, and furthermore discusses the relations of the Boleti to other organisms, the saprophytism of most species, the parasitism of *B. parasiticus* on the false puffball *Scleroderma*, and the important mycorrhizal associations of the species that beneficially aid the roots of forest trees, both coniferous and deciduous.

Beginning with a brief description of the genus *Boletus*, an extensive five-page key is presented to aid the reader in identifying species encountered, followed by detailed descriptions of 68 species and 6 varieties, among which 3 species and 4 varieties are here described as new. This occupies most of the 96 pages of text and most of the illustrations. Following this there is a brief treatment of the four species of the related genus *Boletinus* and of the single common species of the genus *Strobilomyces*.

The book presents the results of Coker's own devotion to the group for many years, combined with the more recent activities of the junior author in an effective collaboration which, together with the help of the artists who furnished the colored illustrations, the aid of the specialists and students who took some of the photographs, and the cooperative reading of the manuscript of Wolf of Duke University, has resulted in a volume of technical merit and wide usefulness. Despite the title, it is by no means limited to North Carolina, as most of the species from neighboring states are included.

As is desirable in a work of this sort, the illustrations materially enhance the value of the monograph. The six color plates illustrating some twenty species, although not equalling the exquisite perfection of the earlier Farlow *Icones*, are exceedingly faithful presentations of important color details, while the 55 half-tone plates are uniformly helpful and excellent. Seven text figures aid in explaining structural characteristics of the genus, particularly the character of the tubes in which the spores are borne, while plates 61–65 are an especially valuable addition, since they show in accurate line and stipple drawings the details of the spore characters on which more and more dependence is being placed in the determination of species in these as well as other genera of the mushrooms.

A literature list of two pages enables the interested reader to follow further not only the classic and technical taxonomic and descriptive literature, but also the aspects of wider biologic interest such as the mycorrhizal association of these forms with forest trees, while a usable index facilitates ready reference to species or to points covered in the text.

The volume maintains the high standards of typography and illustrations for which the North Carolina Press is known; the price is not excessive considering the color plates and the abundant half-tones; all in all, the book is a valuable addition to mycological literature.

A Handbook of Plant Tissue Culture.

By Philip R. White. Jaques Cattell Press, Lancaster. $3.75. 8 x 5½; xiii + 277; 1943.

Although the successful cultivation of animal tissues *in vitro* began early in the present century, the cultivation of plant tissues on a comparable basis did not start until about 1930. In *A Handbook of Plant Tissue Culture* White, who is one of the pioneers in this field, outlines the history, present status, and possible future of this science.

Much space is devoted to describing the techniques of growing satisfactory cultures and utilizing them in the solution of problems of plant physiology, pathology, and morphogenesis. The advantages and disadvantages of various types of meristematic tissues, such as root tips, stem tips, procambium, and cambium are presented. Since carefully controlled conditions are necessary in order to produce results which can be duplicated, a well equipped laboratory is very important. Unfortunately, the ideal laboratory, as herein presented, is quite elaborate and could be afforded only by wealthier institutions. In view of the care which must be given the cultures, it seems doubtful if an inexpensive laboratory could be designed for anything but the most elementary experiments.

Living tissues which are growing *in vitro* must be supplied with mineral salts and certain organic compounds. In fact, one of the aims of growing them *in vitro* is to study their requirements with respect to these substances. For this reason, the preparation of suitable media is described in detail. However, many plant physiologists will wonder why no consideration has been given to hydrogen ion concentration. There is information offered on the effect of this important variable.

The author has devoted a chapter to methods of analyzing and interpreting the results of plant tissue culture experiments. Because of variations in the behavior of living material, often due to unknown factors, numerous replications are needed for each experiment. Measurements are treated statistically.

Although plant tissue culture is a fascinating technique in itself, it is best regarded as a tool which can be used in studying the response of theoretically totipotential plant cells to controlled variations in their chemical and physical environments. There are possible applications to the study of parasitology, but the most promising applications for the immediate future are in the study of factors governing growth and morphogenesis.

Doubtless many plant anatomists and morphologists will disagree with some of White's morphological concepts. Nevertheless, his book is clearly and forcefully written. It represents an important contribution to the field of plant physiology, and in addition, it provides the plant anatomist with a new method of attacking some of his problems. An extensive classified bibliography and an index are provided.

The Flower Encyclopedia and Gardener's Guide.

By Albert E. Wilkinson. Illustrated by Tabea Hofmann. The New Home Library, New York. 69 cents. 8 x 5⅜; xi + 524; 1943.

There are probably very few persons who do not at some time try to grow flowers at home, however small the plot of ground may be. Success often depends upon the application of a few basic principles that may be easily obtained from practical convenient guides such as the present volume. The author, a landscape gardener of experience, has presented in Part I an alphabetical list of familiar and favorite flowers suitable for the home garden, with detailed directions for planting and care during growth. Each flower is described fully and the important types and varieties are clearly differentiated from one another. Common names as well as the botanical names are given.

In Part II, The gardner's guide, factors to be taken into consideration in locating the garden are discussed. Lists of plants suitable for various locations are given and various types of gardens such as Borders, Beds, Rock gardens, Pools, etc. are described and figured. Many useful tables are included, which give the heights of annuals and perennials, color of flowers, and time of bloom, thus enabling the gardener to have pleasing

combinations as well as a succession of blossoms through out the season. Other topics discussed are: soils and fertilizers; propagation; summer, fall, and winter care; the use of hot beds and cold frames; insects, diseases and their control.

The text is appropriately illustrated with simple digrammatic drawings. A very nice glossary defining and diagraming the technical terms used is included at the end of the text.

SHELTER TREES IN WAR AND PEACE.

By Ephraim Porter Felt. Orange Judd Publishing Company, Inc., New York. $2.50. 7¾ x 5¼; 320; 1943.

The need for more careful conservation of our natural resources has been increasingly emphasized during the past two years by the stress of war. Since the shade tree is one of our most highly prized natural resources, both from the standpoint of scenic beauty and of sound agricultural economy, it is entirely appropriate that this excellent little volume on the varieties, the care, and the value of shade trees should appear at this time.

The author introduces his work with a general discussion of the relationship between trees and man, and illustrates as well as describes a number of our old "landmarks", specially emphasizing their beauty, their inspirational values, and their health benefits. A brief section deals with the fundamentals of tree anatomy, physiology, and growth. Numerous valuable suggestions are made for selecting, planting, and caring for trees in a variety of climatic regions and topographical conditions. Finally there is an extensive list of the different species and varieties of trees (giving size, growth and shade characteristics, as well as economic value) common to the United States.

Throughout the volume, there is a plea for wiser conservation of shade trees wherever possible in the construction of roads, buildings, bridges, etc., and for more abundant replanting where native stocks cannot be saved.

The work is profusely and beautifully illustrated and carries a short list of references on shelter trees, as well as a brief index.

THE VEGETABLE ENCYCLOPEDIA AND GARDENER'S GUIDE.

By Victor A. Tiedjens. Illustrations by Tabea Hofmann. The New Home Library, New York. 69 cents. 8 x 5⅜; xi + 307; 1943.

In the present volume the writer appears to have accomplished his purpose admirably, namely "to present in the most convenient form all the information which will be useful to the home vegetable grower". The book is divided into three parts. Part I is an "Encyclopedia of vegetables" and includes in alphabetical order all those commonly grown which are valuable as foods and which also add interest and variety to the garden. Following a description of each vegetable are sections on soil requirements, cultural directions, the prevention and cure of plant diseases, and the control of insect pests.

Part II is a very complete "Encyclopedia of herbs" arranged as in Part I. Both parts are conveniently provided with cross references.

Part III is "The gardner's guide". Here the author brings together important general instructions and suggestions regarding preparation of the soil, fertilizers, selection of seed, transplanting seedlings, handling of tools and equipment, etc. Simple illustrations and diagrams are used to advantage throughout. At the end of the book a table of Spring and Fall frost dates for each state in the union is found as well as a list of the State Agricultural Experiment Stations and the names and addresses of some of the representative seed houses. A glossary of technical terms is included for ready reference.

TREE EXPERTS MANUAL.

By Richard R. Fenska. A. T. De La Mare Company, New York. $4.50. 8¾ x 5⅝; 192; 1943.

This is a book which will interest all home owners whose plot of land is sufficient for the planting of shade or ornamental trees. The artificial conditions under which trees of this type exist make it necessary to give them, in most cases, quite different treatment than is given those living under natural conditions.

The present volume has been prepared specially as a reference and guide for the layman, but others who are more technically concerned with the growth of city and village trees will find it a useful volume to have on hand. The 22 chapters, although briefly and concisely written, contain a large amount of pertinent and up-to-date information. Among subjects dealt with are watering trees, diagnosis of tree trouble, transplanting and pruning trees, dressing wounds, diseases, lightning protection, surgery, tree insects and their control. There is an interesting chapter on the selection of trees for wide, medium, and narrow streets, for moist grounds, for dry soils, for resistance to smoke, dust, and gas. There is even a chapter in which are discussed the laws relating to trees on abutting property, on or near boundary lines, and the owner's responsibility to his neighbor concerning defective trees. The longest chapters in the book deal with diseases of trees, insect infestation, and insecticides and fumigants.

The volume is abundantly illustrated. It is unfortunate, however, that, in so useful a book, some of the illustrations are not better reproduced. The index has been prepared with care, and the reader will find it extremely useful.

SHRUBS AND TREES FOR THE SMALL PLACE. *Hardy Deciduous Materials for the Home Grounds.*

By P. J. Van Melle. Charles Scribner's Sons, New York. $2.50. 8¼ x 5⅛; 298; 1943.

This book is written to give the novice a comparative evaluation of a wide range of hardy, ornamental, deciduous shrubs, and small trees useful in small home landscapes. The author has selected from the broad range of available shrubs and small trees about four hundred which are capable of enduring severe winters and therefore are of interest to gardeners over a wide part of the country.

One quite unique feature is the presentation of a score-chart containing 363 listings in which the shrubs and trees are scored comparatively on the basis of points allowed for what appear to be the requisites of good shrubs, such as floral effect, floral fragrance, normal foliage value, seasonal foliage color, decorative fruit, summer blending value, relative freedom from insect pests and diseases, transplantability, endurance of light shade, and adaptability to various soils. A descriptive review of the material contained in the chart follows, after which there is a brief discussion and review of shade trees for the small place. The last few chapters deal with pruning, factors which govern hardiness, and planting operations.

The book is unusually informative and practical and is written with a minimum use of technical terms. It deserves attention.

STUDIES OF EVAPORATION AND TRANSPIRATION UNDER CONTROLLED CONDITIONS. *Carnegie Institution of Washington Publication 550.*

By Emmett Martin. Carnegie Institution of Washington, Washington, D. C. 40 cents. 10 x 6¼; 48; 1943.

Evaporation and transpiration in plants have been subjected to the scrutiny and ingenuity of many investigators, but for the most part, have defied any and all attempts at qualitative or quantitative analysis or description.

The present study is a worthy contribution to the specific problem of evaporation and transpiration under controlled laboratory conditions. The relationships between a variety of physical factors (temperature, air currents, surface area, and light) and the gain and loss of water in several plants are described in the light of numerous carefully planned and completed experiments. Among the significant findings herein reported are: (1) that considerable variation was noted in the relative transpiration between young and old plants; and (2) that small leaves are affected less by extreme temperatures than are the larger varieties. The latter factor is probably significant in the conservation of water among the small-leaved species of plants common to desert regions.

The bibliography includes 39 papers relating to the general problem of evaporation and transpiration.

MORPHOLOGY

EDWARD TYSON, M.D., F.R.S. 1650–1708 *and the Rise of Human and Comparative Anatomy in England. A Study in the History of Science. Memoirs of The American Philosophical Society Held at Philadelphia for Promoting Useful Knowledge. Volume XX.*

By M. F. Ashley Montagu with a Foreword by George Sarton. American Philosophical Society, Philadelphia. $5.00. 9¼ x 5⅞; xxix + 488; 1943.

Edward Tyson generally has been known merely as the author of "*Orang-Outang, sive Homo Sylvestris:* OR, THE ANATOMY OF A PYGMIE Compared with that of a *Monkey*, an *Ape*, and a *Man*", the earliest account of the anatomy of a chimpanzee. Save this, the man has remained in relative obscurity. Now, thanks to the scholarly and painstaking researches of Montagu, he emerges as a figure of outstanding importance in the history of Comparative Anatomy.

Tyson was born in Bristol, England, in the year 1650, and died in 1708. He studied at Magdalen Hall, Oxford, receiving the degrees of B.A., M.A., and M.B. Having acquired an early interest in anatomy, he quickly gained an enviable reputation in that field and was elected a Fellow of the Royal Society in 1679, when less than 30 years of age. He received an M.D. at Cambridge one year later. Tyson moved in a brilliant circle. Such men as Isaac Newton, Robert Boyle, Thomas Sydenham, John Ray, Thomas Willis, Christopher Wren, Robert Hooke, and Nehemiah Grew were his contemporaries, and the latter two were his close friends. Although he became a busy and successful practising physician, Tyson retained and pursued his biological interests throughout life. Thus he published, among others, excellent accounts of the anatomy of the harbor porpoise (1680), of the rattlesnake (1682/83), of the Mexican musk-hog (1683), of the Virginian opossum (1698), and, finally—with the aid of William Cowper—of the chimpanzee (1699).

Tyson emerges from this biography as a broadly educated and scholarly man, an able physician and human anatomist, and a comparative anatomist of outstanding achievement and unusual originality. Montagu's book makes extremely easy reading and is a solid contribution to the history of science as well. Not only does it discuss the scientific accomplishments of Tyson and the more important features of his life, but it also depicts the scientific and medical England in which he worked and lived.

The real problem comes in assessing Tyson's true historical significance. Certainly, the claim of his present biographer that the *Anatomy of a Pygmie*—for all its significance—is of an historical importance

equal to that of the *Fabrica*, the *Revolutiones*, and the *Principia*, appears to have been born of sheer enthusiasm. Tyson—and indeed this does him no dishonor—simply was not of the same stature as Vesalius, Copernicus, or Newton. Montagu bluntly states that Tyson was "the Father of Comparative Anatomy in England" and "the greatest of England's comparative anatomists". Despite Tyson's obvious distinction, both of these pronouncements certainly are open to question. For to be a father one must have children, and Tyson was without direct scientific heirs. He founded no school of Comparative Anatomy, and while his published works undoubtedly influenced general biological thinking, Comparative Anatomy remained essentially fallow in England from his death until the coming of John Hunter (1728–1793)—actually for over 50 years. And it is with Hunter that the unbroken stream of English Comparative Anatomy really begins. One cannot yet say how much Hunter may have owed to Tyson. Truly, there are some striking resemblances between the two men in their scientific points of view, although Tyson was widely read and erudite whereas Hunter was relatively uneducated and uncultured. Both placed great emphasis upon the physiological significance of structure, and both were greatly occupied with studying the gradations or transitions between animals. But these interests were not novel; they can, indeed, be traced back into antiquity. Ascription of intellectual paternity frequently can at best be but arbitrary and inconclusive, and so it would appear to be in the instance of English Comparative Anatomy. The same too often is true in the determination of relative greatness, and herein one is inclined to agree with Dogberry, the constable, that "comparisons are odorous". But if candidates for the title of "the greatest of England's comparative anatomists" are to be designated, what of Hunter and Richard Owen? In both productiveness and influence, each far surpassed Tyson, for all his accomplishments.

On the other hand, there seems little question that the biographer is justified in his claim that Tyson was the true founder of what has come to be known as "Primatology". Tyson's description of the chimpanzee as presented in his truly remarkable *Anatomy of a Pygmie* was the earliest published account of the anatomy of an anthropoid ape. Not only is it most admirable in quality, but it also was novel in that it demonstrated, for the first time, that this animal in many respects is intermediate between monkeys and man. Thus Tyson clearly posed—although he was no evolutionist—the problem of man's descent, a problem still far from solution. Furthermore, he introduced a method of comparison still widely used—unfortunately, however, too often uncritically—in the study of primates. Hence all workers in this field must forever remain in his debt.

FUNDAMENTALS OF CYTOLOGY.

By Lester W. Sharpe. McGraw-Hill Book Company, New York and London. $3.00. $8\frac{3}{4}$ x $5\frac{3}{4}$; x + 270; 1943.

Those who ever tried to teach cytology to students with little background in biology know the difficulties in presenting a field, as diversified and full of controversies as is this field, in simple terms and still do it justice. The author of the well-known *Introduction to Cytology* attempts in this book to bring the discoveries and ideas of cytology to the general student, and he has largely succeeded in doing it in a clear, precise and yet fair fashion. The chapter headings give an idea of the broad scope of the book: 1. The position of cytology in biological science. 2. The organism and the cell. 3. The structural components of protoplasts. 4. Protoplasm. 5. Division of the protoplast. 6. The cell walls of plants. 7. The chromosomes. 8. Meiosis. 9. Cytology of reproduction in animals. 10. Cytology of reproduction in Angiosperms. 11. Cytology and reproduction in plants other than Angiosperms. 12. Cytology and Mendelian heredity. 13. Chromosomal aberrations. 14. Chromosome numbers and their alteration. 15. Cytological aspects of hybridity. 16. The rôle of the cytoplasm in development and heredity. 17. Cytology and taxonomy.

To make the book more readable, references are not included in the text. It is, however, regrettable that the names of the most important contributors have been mostly omitted even in cases of specific examples. A few references to each chapter are added at the end of the book. One often wonders, however, why a particular reference is given while much more important contributions are not cited. The animal cytologist also will regret that animal material has been treated too often as a stepchild, not only in the references but also in text and illustrations. While in some fields like cytogenetics or cytology in relation to taxonomy emphasis on plants is justified, the chapters on cytoplasmic components, cell division, meiosis, and reproduction suffer from inadequate consideration of the animal side. It also would add to the value and interest of the book if "physiological cytology" were given somewhat more space. The specialist may disagree here and there with selection or emphasis, but, on the whole, it is an outstanding feature of this textbook that facts have not been sacrificed for the sake of simplicity and uniformity. The more astonishing, then, it is to find the diagram of meiosis based on the assumption that leptotene chromosomes consist of single strands, a notion which has been disproved both for animals and plants.

These shortcomings, however, are trivial in view of the general value of the book. The clear, simple, and precise style can hardly be surpassed and especially the summaries at the end of the chapters are masterly. The illustrations are plentiful, well chosen and well

reproduced. To both teacher and student *Fundamentals of Cytology* will be most helpful and it can contribute a great deal to dispel the popular notion that cytology is a "secret science" clogged with terminology and consisting of counting chromosomes or describing artifacts.

AN ATLAS OF ANATOMY. *In Two Volumes. Volume I. Upper Limb, Abdomen, Perineum, Pelvis, and Lower Limb. Volume II. Vertebrae and Vertebral Column, Thorax, Head and Neck.*

By J. C. Boileau Grant. The Williams & Wilkins Company, Baltimore. $10.00. 11 x 8½; Vol. I, xv + 214, Vol. II, xv + 184; 1943.

The gross anatomical structures of the average adult human body have been abundantly described and illustrated in a great many textbooks and atlases and there is very little left that might be added as something new. Indeed, the stage has been reached at which it might seem desirable from the point of view of medical education to reduce the contents of our ponderous anatomical books, if they are to be of real service to our harried medical students.

This new atlas depicts man's body region by region, much as the beginner proceeds during dissection. Emphasis has been placed more on topographic relations than on the systematic presentation of anatomy. It is evident that the work was planned to satisfy the needs of medicine and is not concerned with the broader interests of biology.

The illustrator for these volumes is Mrs. Dorothy Chubb, a pupil of the late Max Broedel, the great master of art as applied to medicine. This atlas contains a total of 460 figures consisting of diagrams, pen-and-ink sketches, half-tone drawings, and colored plates. All these illustrations are new and carefully prepared to show significant conditions to best advantage. The selection of the subjects pictured and the views in which they are shown are very useful and in many instances quite novel. The labeling is clear, limited to essentials, and follows the Birmingham Revision of the *Basle Nomina Anatomica* (with *B. N. A.* terms in brackets whenever the revised terms differ markedly). The half-tone drawings were based upon photographs of actual preparations to ensure correct proportions and have been executed with rare technical skill. They are well reproduced, of generous size and give the effect of remarkable plasticity.

This atlas is not a mere pictorial catalogue of the typical macroscopic structures of the adult human body, but fortunately does include occasional references to significant variations, developmental defects, secondary sex differences, and age changes, though the examples shown are all too scanty and somewhat arbitrarily chosen. The purely descriptive treatment of human anatomy, limited to one age stage of one animal form, would be most monotonous and even artificial without reference to nature's versatility in producing normal as well as abnormal variations and without at least calling attention to some of the typical differences due to age, sex, etc.

This new, well-printed and reasonably priced atlas can be highly recommended to medical students, practitioners and investigators most of all on account of its many novel views of anatomical structures and because it does ignore some of the least important items. It should be emphasized, however, that the atlas does not obviate the need for the more comprehensive and systematic collections of anatomical illustrations and texts. Each volume has a separate and fully adequate subject index.

HUMAN NEUROANATOMY.

By Oliver S. Strong and Adolph Elwyn. The Williams & Wilkins Company, Baltimore. $6.00. 9¾ x 6¾; x + 417; 1943.

It has not been many years past that the teacher and student had but a relatively narrow choice in the matter of texts dealing with neuroanatomy. All that now is altered. The last few years have produced what almost amounts to a plethora of books on this subject. Many of these have succeeded in doing little more than confuse the student, and in general they have contributed but slightly to the advance of pedagogy in this field.

The present text-book is a noteworthy exception in that it is a real contribution. In the strict sense, it is a new book. Actually, however, it is the direct heir of the section on the central nervous system, written by the same authors, that formerly was a part, until some ten or so years back, of Bailey's *Text-book of Histology*. In its new form it unquestionably represents one of the best of the current texts on neuroanatomy, and the reviewer is not certain that it is not the very best. It has a sound biological point of view and maintains a nice balance between nervous structure and function, both aspects of the subject being presented, as the title indicates, with special emphasis upon man. The text is scholarly and complete, for the recent literature has been given due consideration. The 320 illustrations are well chosen and excellently reproduced. There is a useful reference list of literature.

One particular bit of nomenclature—still, unfortunately, too generally in use—is particularly irksome to the reviewer, namely, the continued use of the term "special visceral efferent" to designate the motor components of cranial nerves V, VII, IX, X and XI that supply striated musculature. In view of recent knowledge relative to the components of the cranial nerves

and to the so-called "branchiomeric" region in general, this term has become devoid of any real significance and definitely should be discarded. At best, it merely serves to adumbrate matters for the beginning student.

THE CHROMOSOMES.

By M. J. D. White. The Chemical Publishing Company, Brooklyn. $1.50. 7¼ x 4¾; viii + 128; 1937.

It may seem somewhat belated to review a book which was published in 1937. Yet as it has become available again in this country, through the Chemical Publishing Company, it is well worth while to call it to the attention of those who may not have known it before. In the last fifteen years chromosome cytology has seen a rich harvest of discoveries. White undertakes to bring the essence of this new science of chromosomes to a wider public. The book is organized into an outline of mitosis and special problems of mitosis, an outline of meiosis and special problems of meiosis and ends with a chapter on chromosomes and evolution. The main shortcomings of the well-written booklet is the oversimplification and dogmatic attitude for the sake of a well-rounded story. The most controversial subjects are discussed as if the major problems were already solved. Thus what appears to be an advantage of its presentation, coherence and simplicity, is gained only at cost of accuracy and completeness. In some fields there has been, furthermore, great advance in the last few years so that some parts of the discussion are no longer up to date. However, if it is kept in mind that very often the discussion is one sided and sometimes out of date the booklet can be used with great advantage as an introduction to the structure, behavior and general significance of chromosomes.

A TEXTBOOK OF ANATOMY AND PHYSIOLOGY. *Seventh Edition, Revised.*

By Jesse Feiring Williams. W. B. Saunders Company, Philadelphia and London. $2.75. 7¾ x 5¼; x + 573; 1943.

The fact that this book has gone through seven editions is ample evidence that it has found a place in the teaching of short courses dealing with elementary human anatomy and physiology. In the preface the author states that, "The book is designed to serve the needs of the student of anatomy and physiology outside the medical school". It is possible that the needs of students of nursing or physical education, which he mentions specifically, may be met by such a volume. However, it is difficult to see how it is adapted to the needs of non-medical students who are interested in anatomy or physiology as such.

The material is selected almost entirely from human anatomy and physiology which does not appear to be an adaptation for the non-medical school student, and represents a combination of very elementary and very complex material. Questions such as "What is a nerve?" and "What is a ganglion?" found at the end of chapters on the nervous system indicate that no previous knowledge of the subject by the student is assumed, and yet the same chapters include a rather extensive use of detailed medical terminology relating to the tracts and areas of the brain and spinal cord. Inasmuch as medical terminology is usually one of the last things mastered by the non-medical student of anatomy it is doubtful if many of them are capable of adequately utilizing this combination of simple and involved material when presented in a condensed course.

Although a number of small additions and rearrangements have been made in this edition, nothing has been done to markedly alter its nature, and it should serve essentially the same function as previous editions. Its place would seem to be in what might be called diluted medical-school courses which are not intended to form a basis for further work in anatomy or physiology, and in which the broader aspects of comparative anatomy and general physiology are not considered.

AN ATLAS OF THE BASAL GANGLIA, BRAIN STEM AND SPINAL CORD *Based on Myelin-stained Material.*

By Henry Alsop Riley. The Williams & Wilkins Company, Baltimore. $13.50. 8½ x 11; [ix] + [708]; 1943.

This is an absolutely unique contribution to neuroanatomy. Based on myelin-stained material, it comprises 254 enlarged photographs of transverse, horizontal, and sagittal sections of the human spinal cord, brain stem, and basal ganglia. That there has been great need for such an atlas has been all too evident. It is not in any sense a text-book, but a reference work; and as such it undoubtedly will be widely used by students, investigators and clinical neurologists. The photographs are excellent and are superbly reproduced. There also is appended a complete list of the structures considered in the illustrations, with their symbols and a brief, useful descriptive text. If any fault is to be found, it is with the labelling, which frequently obscures details and at times is annoyingly difficult to follow. The odd format of the book will tax any but the deepest of bookshelves.

APPLIED ANATOMY OF THE HEAD AND NECK *for Students and Practitioners of Dentistry.*

By Harry H. Shapiro. J. B. Lippincott Company, Philadelphia. $5.50. 10 x 6¾; xiv + 189; 1943.

This book describes the anatomy of head and neck and correlates it with clinical applications. Although

written primarily from the viewpoint of the dentist, it also should prove of considerable value to medical students and anatomists; for it emphasizes certain aspects—as relating to oral cavity, jaws, and teeth—usually not stressed in ordinary anatomical texts. There is a chapter devoted to development and growth of oral and associated structures, and one dealing with the problems of war surgery as related to the dentist. The illustrations are numerous and well chosen. There is an index.

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY. *Vol. 47, No. 6. The Golgi Apparatus in Uterine Gland Cells During Pregnancy in the Rabbit*, by B. Krichesky and H. Mandel. *Vol. 47, No. 7. Anatomic and Histologic Studies of the Sex Accessories of the Male Rabbit*, by Howard Alan Bern and Boris Krichesky.

University of California Press, Berkeley. No. 6, 25 cents; No. 7, 35 cents. 10¼ x 6¾; No. 6, 6; No. 7, 21 + 4 plates; 1943 (paper).

PHYSIOLOGY AND PATHOLOGY

VASCULAR SPASM: EXPERIMENTAL STUDIES. *Illinois Medical and Dental Monographs, Volume III, Numbers 3–4.*

By Alexander John Nedzel. University of Illinois Press, Urbana, Illinois. $2.25. 10⅞ x 8; 151; 1943 (paper).

This is an experimental approach to the general question of the importance of vascular spasm in the production of disease syndromes. The matter may be briefly stated as follows, that the internal economy of the body depends upon the interfunction of the autonomic nervous system, the endocrine glands, and the blood chemistry, and the ultimate effects of this interfunction on any area of the body is related directly to the status of the capillary bed at that point. The capillaries normally undergo a rhythmic dilatation and contraction, depending itself on the smooth functioning of the autonomic nervous system.

The vascular bed may be roughly divided, as far as its relationship with the autonomic nervous system is concerned, into a splanchnic and a peripheral system which act in opposite directions with shift of blood masses occurring from one to the other in response to environmental and experimentally induced changes. The peripheral system comprises the skin and its constituent structures. The splanchnic system includes such important organs as the kidney, liver, gastrointestinal tract, and the central nervous system.

The author has shown that experimental injections of pitressin lead to scattered lesions in the splanchnic system as a consequence of localized vascular spasm in the capillaries. For example, a non-bacterial endocarditis and histologic lesions in the gastric mucosa and even in the central nervous system could be produced by this method. Experimentally induced bacteremia in connection with such pitressin injections produced rather typical bacterial endocarditis, differing essentially from the non-bacterial endocarditis only in the fact that bacteria had tended to accumulate at the areas previously touched by pitressin injections. In one case bacterial endocarditis occurred after pitressin injection alone. This may be assumed to have been due to the presence of an endogenous bacteremia at the time of the pitressin injection.

The author's main contention is that numerous disease pictures, for example, endocarditis, gastric ulcer, certain lesions of the liver and kidneys, and even multiple sclerosis have for their ultimate causation disturbed control of the autonomic system resulting in prolonged or too frequent vascular spasm of the capillary bed with pathologic tissue change resulting from it, with or without superimposed bacterial invasion at the site of the lesions.

This monograph appears to be a follow-up of Petersen's work on the influence of meteorologic factors on the production of disease. The author's observation of the effect of heat and cold are not as telling or dramatic as his experiments with pitressin. He draws attention to the fact that he was working with what may be presumed to be normal animals, whereas physicians deal with people with deranged autonomic systems in the sense of being overly labile, or people laboring under emotional disorder, etc. Whether this gets back finally to constitution he doesn't express an opinion, except to point out that people with labile autonomic systems are usually either thin or fat.

The book is handsomely illustrated with microphotographs of exceptional clarity. As an experimental approach to the question of the etiology of numerous disease pictures, the book makes a welcome contribution. The author offers no clues as to why in certain individuals, either rats or humans, there seems to be a preference for vascular spasm and its unfortunate consequences to occur in this, that, or the other organ. Only psychoanalysts have ventured a ready answer to this question.

THE SCIENCE OF NUTRITION.

By Henry C. Sherman. Columbia University Press, New York. $2.75. 8¾ x 5½; x + 253; 1943.

It is stated on the cover of this book that it is intended for those "... with scientific curiosity, but no specific training in science", and it seems to be admirably suited for readers falling into this classification. Unlike many nutrition books, it is much more than a compilation of tables of the caloric values and vitamin contents of various foods, and makes a serious attempt to get across to the reader the real significance of recent advances in our knowledge of nutrition.

The book may be roughly divided into two sections. The first deals with our current knowledge of nutritional needs and how they may be fulfilled, while the second takes up the ever present problem of how this knowledge may be utilized for the betterment of mankind. In the first section, various nutritional factors are discussed and the caloric, protein, vitamin, and mineral contents of a short list of selected foods are given. Our current knowledge of these various dietary factors is discussed from an historical point of view, and although these accounts are necessarily incomplete, they do provide an interesting insight into the methods and the reasoning involved in nutritional research. The author also discusses briefly the rôles of various foodstuffs in the body and certain related features of assimilation and intermediary metabolism.

Throughout the book, the author places considerable emphasis on the difference between optimum and merely adequate nutrition. Many people still fail to realize that the absence of obvious deficiency symptoms is not an adequate basis upon which to interpret a given diet as suitable, and Sherman continually points out the prolongation of active life and the improvement in general health that may be obtained through an optimum diet.

The second, and perhaps the most interesting, portion of the book deals primarily with the social implications of nutritional knowledge. The author recognizes that large sections of our American population are living on nutritionally "poor" diets, and that many of the limitations of achievement recognized in certain sections of our population may have a nutritional basis. He then discusses methods through which this situation might be alleviated. As in most books of this kind, considerable emphasis is placed upon the education of the public. This is undoubtedly important, but the author goes beyond this in pointing out that ". . . it has also been clearly shown that even without education the great majority of low income families do provide themselves with nutritionally better dietaries as soon as their purchasing power is increased." He recognizes the Government's responsibility in developing an adequate nutritional policy and points out that "subsidized consumption" is not "too paternalistic" in present-day America, although it is often attacked on this basis because of prejudice or as a further entrenchment of the "vested interest" point of view. Nutrition is as much the concern of Government as education, and indeed, expenditures on education may frequently fail to produce the desired results because of a lack of attention to the nutritional needs of the students.

This book not only provides concrete information on the science of nutrition, but also adopts a realistic attitude toward the larger problems, and responsibilities growing out of our increased knowledge in this field. It is a really valuable book and should prove to be both interesting and instructive to anyone with scientific curiosity and an open mind.

The volume is provided with a good index, and a rather extensive selected bibliography.

THE PRINCIPLES AND PRACTICE OF WAR SURGERY: *with Reference to the Biological Method of the Treatment of War Wounds and Fractures.*

By J. Trueta with an Introduction by Owen H. Wangensteen. C. V. Mosby Company, St. Louis. $6.50. $9\frac{3}{4}$ x $6\frac{3}{4}$; 441; 1943.

Trueta's account of his surgical experiences during the recent war in Spain has made him well known to American students of surgery. His advocacy of encasement of injured extremities in plaster-of-Paris casts struck a familiar note and a sympathetic interest among his American readers. This larger and more inclusive discussion of the problems of military surgery should find a warm reception in this country. When the results obtained with the treatment that forms the subject of this book were first reported in Great Britain, the immediate reaction was one of skepticism. Much has happened since then, however, and the spread of the war has offered many occasions for putting the treatment, and the claims made for it, to the test. Among others, Cohen and Schulenburg, Shepherd, Ball and Qvist, Wilson, Scott, Higgs, and workers at the Wingfield-Morris Orthopaedic Hospital in England have published the results of a total of over 450 cases treated with the Trueta technique, with only three deaths. The author feels that these results conclusively prove the value of his method. A second fact which emerges from experience in Great Britain is that the quality of the results is to a large extent independent of the surgeon's skill, and that success depends mainly on a clear understanding and careful practice of the principles on which the method is based. In the appearance of this new Trueta book in an American edition, it is perhaps not out of place to point out that Frederic S. Dennis, a New York surgeon,incorporated in his practice with considerable success, sixty years ago, the principles of wound revision and fixation very much as we know them today.

The present volume is presented in two parts, the first of which is concerned with the pathology of war wounds and general care of the wounded, including: biological principles of treatment, development of war surgery, healing of wounds, infections, gas gangrene, tetanus, shock, traumatic vascular spasm, blood transfusion, and anaesthesia in wartime. In the second part, on essentials of war surgery, the following topics are discussed: the essentials of treatment and organization, antiseptics, chemotherapy, wound excision, drainage, reduction and fixation of fractures, immobilization, plaster-of-Paris technique, primary and secondary sutures, skin graft in war surgery, articular wounds, amputation, regional surgery, and burns.

The book is generously illustrated with a judicious

selection of drawings, charts, tables and photographs, all of which add greatly to its usefulness to students and practitioner alike. There is a complete bibliography and an index. Students and civilian surgeons, as well as those in the armed forces, are urged to become familiar with the contents of this volume.

BACTERIOLOGY *for Students of Medicine and Public Health.*

By Einar Leifson. Paul B. Hoeber, Inc., New York and London. $5.00. 9¼ x 6¼; xvii + 526; 1943.

"As more and more knowledge is added to the medical sciences, the load on the medical student becomes increasingly heavier." No statement could be truer than that expressed by this opening sentence of the author's preface. One of the greatest problems of the medical school faculty is the selecting of material to be presented in the time available for the various courses. If the practical facts are selected to the exclusion of the theoretical background, the student is seriously handicapped by not obtaining a broader appreciation and understanding of the subject. This was a major concern even before the present war, but now with the accelerated programs it has developed to a critical state. A student can grasp and retain only a certain amount of information within a given period of time, and it becomes the responsibility of the teacher to decide just what information will be of the greatest value in later years. Leifson is fully aware of this problem and has been conscious of his responsibility in the preparation of his text. He has succeeded in combining the theoretical with the practical in a volume of medium length. This should make it a desirable textbook for the subject of bacteriology in many medical schools. Although it has been specifically written for this purpose, the subject matter presented should also make it a good textbook for other groups of students.

The author has wisely separated the material into various phases of the subject. This has been done in order to make it easily adaptable to the desires of various types of teachers. For instance, there is a section on Bacteriology as related to agriculture and industry. Although this section is only sixteen pages in length and would be of cultural value to the medical student, some teachers might think it advisable to exclude it from consideration in their courses. There are two sections of definite practical value to this group of students, but due to one reason or another might not fit into the particular course that is being offered. These sections deal with fungi, protozoa, and the principles of biostatistics and epidemiology. The remaining five sections would seem to be essential to all bacteriology courses offered to students of medicine and public health. In these are presented the general biology and classification of bacteria, the principles of immunity, the infectious diseases of major importance, and descriptions of standard laboratory techniques. Although it is entitled "Bacteriology," it is actually a textbook of medical microbiology inasmuch as the filterable viruses, rickettsias, fungi, and protozoa are likewise considered to a certain extent.

The subject matter is presented with clarity and interest. Furthermore the 150 figures and 54 tables contribute greatly to the volume's attractiveness and practicability. Many of the photomicrographs are excellent. A twelve-page index concludes the volume.

DIAGNOSIS OF UTERINE CANCER BY THE VAGINAL SMEAR.

By George N. Papanicolaou and Herbert F. Traut. The Commonwealth Fund, New York. $5.00. 11 x 8; x + 47 + 11 colored plates; 1943.

One of the greatest challenges to the medical scientist is to discover better diagnostic procedures, particularly those that are applicable early in the course of the disease. The authors of this book have accepted this challenge and present the details of a diagnostic technique which they believe is helpful in discovering the presence of uterine cancer while it is still in the incipient stage.

The vaginal secretions contain a great variety of cells that have distinct morphological characteristics as revealed by a rather simple staining procedure. It has previously been shown by the present authors and other investigators that these cells vary with the different phases of the menstrual cycle and other normal physiological conditions. More recently, it has been demonstrated that cancerous growths of the uterus shed superficially placed cells that accumulate in the vagina. In the present work the authors review the appearance of the normal cells and describe the cancerous cells found in the vaginal smear. In addition to the detailed descriptions of cellular morphology and staining affinities, the various cells are illustrated by colored drawings and photomicrographs. Eleven page-size plates are required to present this valuable section of the book.

The information presented is based upon the careful examination of seven to ten thousand vaginal smears prepared from the vaginas of 3,014 adult women. Most of these were obtained as part of the routine examination of the female hospital patients, while others were obtained from patients diagnosed as having uterine cancers before admission. In all there were 193 instances of carcinoma involving the uterus and other parts of the lower genital tract. Although there were seven occasions in which the vaginal smear failed to demonstrate the presence of malignant growths, it was the primary method of diagnosing the presence of nine others. It was found to be more effective in revealing carcinoma of the cervix than of the fundus. If the postradiational cases are excluded,

the vaginal smear succeeded in diagnosing all but 1.6 per cent of the cancers at the first location and 9.3 per cent of those at the second.

The generally accepted method of diagnosing uterine cancers is the pathological examination of material obtained by curettage and biopsy. It has great disadvantages of being expensive and time-consuming. This being the case, not many women can avail themselves of the examination. On the other hand, the vaginal smear method is simple, inexpensive, and quickly performed. It can, therefore, be included in the routine examination of large numbers of women with the possibility of revealing early incipient cancers. The authors do not maintain that it should be relied upon for the final diagnosis, but that it might serve as a lead to be checked by the more critical examination. Whether or not it will prove to be practical will be determined by the number of medical men who will study this manuscript and attempt to use the diagnostic method described.

THE CONQUEST OF EPIDEMIC DISEASE. *A Chapter in the History of Ideas.*

By Charles-Edward Amory Winslow. Princeton University Press, Princeton. $4.50. 9¼ x 6½; xii + 411; 1943.

This book presents an historical account of the slow and gradual evolution of human thought on explanations for the occurrence of epidemic disease. It begins with the idea that pestilence is due to the influence of demons, witches, and spirits; then it carries the reader through the centuries to the modern germ theory and its application to epidemiology. There were many temporary set-backs in the chain of ideas that finally led to the present day conception of the problem. No great progress could be made until there was definite proof for the existence of germs. This came after the discovery of the microscope by Leewenhoek and the experiments of Pasteur. It is interesting in this connection that for nearly 2000 years before sufficient proof was accumulated, the laymen were generally contagionists and the physicians were miasmatists. The author explains this as follows. "The layman observed certain obvious phenomena and jumped to the conclusion of contagion. The physician, knowing more, was quite correct in denying that any *then-available* theory of contagion could explain the facts."

In writing this history of an idea, the author has, whenever possible, used the actual words of the various participants. This adds much to the interest and authenticity of the manuscript, but on many occasions it makes the reading disjointed and a little difficult. This is particularly true in the first few chapters. The reading is much smoother in the later chapters where more and more the author expresses the development in his own words.

At the end of the book an extensive reference list is given. It is divided according to the eighteen chapters of the text. Two indexes are included, an index of persons and an index of subjects.

It is well to end this review with the closing remarks of the author:

> We shall never return to the demonic and miasmatic theories of the past; and the practical application of the principles developed by a series of clear thinkers and brilliant investigators—from Fracastorius to Chapin—has forever banished from the earth the major plagues and pestilences of the past. To trace the evolution of the theoretical concepts which have made this triumph possible has been the purpose of the present volume.

DOCTOR IN THE MAKING: *The Art of Being a Medical Student.*

By Arthur W. Ham and M. D. Salter. Illustrations by Jean McConnell. J. B. Lippincott Company, Philadelphia. $2.00. 7½ x 5; xi + 179; 1943.

For several years Ham and Salter have dealt with the problems confronting the medical students at the University of Toronto. Their observations soon led them to the conclusion that "ability and academic preparation do not guarantee success." Of course, these two qualifications are essential, but they also noted that there were many more—such as habits of study, attitudes, and general personality characteristics that are less obvious but none the less important. In this little volume, the authors have attempted to point out these secondary qualifications to the prospective medical student and to offer hints and suggestions as to how an individual might better insure his success in the event that he discovers himself deficient.

In the opening chapter, the authors urge the individual to analyze his motivations for desiring to study medicine. In doing so, they do not try to discourage him by painting a morbid picture of the practice of medicine, but simply remove a little of the glamour in an attempt to make the student approach the undertaking realistically. Then they present the major portion of the book—Enemies of success and how to defeat them. They discuss such problems as daydreaming, forgetting, allocation of time, and organization of knowledge. In the closing chapter, they present the responsibilities of the medical student to the medical profession and to society. Here a number of the "do's and don'ts" are considered.

The book is literally filled with helpful hints and sound advice. Although it was written specifically for medical students, practically all of the contents are equally applicable to the study of any subject, graduate or undergraduate. It is written in a light, inter-

esting style and is illustrated with amusing, but instructive cartoons. It has an index that can be used by the student for seeking advice on definite problems.

AIR-BORNE INFECTION. *Some Observations on Its Decline.*

By Dwight O'Hara. The Commonwealth Fund, New York. $1.50. 8½ x 5½; ix + 114; 1943.

As we entered the last war the health and well-being of our troops were threatened by air-borne infection quite as much as they were by the more obvious hazards of armed conflict. As we entered the present war the health and well-being of our troops did not seem to be threatened by air-borne infections as they were twenty-five years ago. During the first year of mobilization, prior to Pearl Harbor, deaths from all causes did not reach the proportionate figure that deaths from measles alone reached in 1917. The six diseases that normally killed 330 per hundred thousand population in Massachusetts in 1917 account for a scant 100 now, and this experience is not confined to this state alone. Clearly a change has taken place, a change the gross implications of which must be far-reaching. Analysis of the background for this change, if it could be made objectively and with good perspective, might well provide material from which a blueprint for the maintenance of respiratory health could appear. The author feels that somewhere in our immediate social past something has happened which, if recognized and properly interpreted, can promise a desirable and hopeful outlook for the future. For this recognition and interpretation the present book is offered—to record as accurately as possible a fair appraisal of what has happened and how it has happened, for whatever it may be worth in our future planning. In other words, these pages represent an outlook upon the general phenomena of respiratory infection, expressed in 1942, and here recorded with full realization of the fact that it deserves a greater maturity of thought than it has yet received.

The chapter headings are: scope of preventive medicine, smallpox, diphtheria, air-transfer of disease, the common cold and others, pneumonia, streptococcus infections, rheumatic fever, tuberculosis, natural amelioration, raw material of health, and the ageing process. The book is illustrated with charts, graphs, and maps. The references are given as footnotes. There is an index. This volume should prove valuable to every physician and public health officer.

TUBERCULOSIS AS IT COMES AND GOES.

By Edward W. Hayes. Edward W. Hayes, Monrovia, California. $2.00. 7⅜ x 5; 187; 1943.

Recollecting his own feeling when he was on "the cure", and judging from experience with his patients since then, the author says he believes that the more a physician takes his patient into his confidence regarding tuberculosis in general, and the patient's condition in particular, the more gratifying will be the results. It was apparently with this idea in mind that this little book was written. The author hopes that it will be studied much as a textbook is studied, so that the subject-matter may become a part of the reader's general knowledge. Needless to report, those who do become familiar with the subject-matter of the book can expect to be well fortified in their efforts to avoid or combat the disease, as the case may be. It is intended that the book will, in brief form, give a general idea of the cause and nature of tuberculosis, as well as a correct idea of its treatment. This will enable the reader to discuss intelligently with the physician the details of any particular case and make it possible for him to comprehend the reasons for the various phases of the cure as they are outlined. There is also every reason to believe that this monograph may well serve at least a small part in the educational campaign which, in the absence of any specific treatment, must be universal if tuberculosis is to be overcome.

Subject-matter presented includes the following: history of tuberculosis, the tubercle bacillus, theories of infection and its control, infection versus disease, incidence, classification of pulmonary tuberculosis, diagnosis, treatment, diet, climate, heliotherapy, time, mechanical therapy, the various forms of collapse therapy, the use of drugs in treatment, complications, pulmonary hemorrhage, pregnancy and tuberculosis, curability, prognosis, and suggestions to visitors. There are drawings to illustrate the various types of tuberculosis and to show the kinds of collapse therapy commonly used. This highly helpful and informative little book concludes with an appropriate bibliography and index. A careful reading will bring real reward to all those concerned with the conditions discussed.

NEW ASPECTS OF CHEAP FOOD: *with a Table of Foods in alphabetic order showing in a single figure the comparative value in nutritive units of potato.*

By Rudolph Keller. Research Books, Limited, in association with William Heinemann, London. 1/6 net. 7½ x 4¾; 52; 1943 (paper).

This valuable little book surveys the scientific and economic aspects of nutrition as they confront the world at the present time. The author is an authority on dietetics and his laboratory in Prague had a European reputation. His teachings and research there were closely associated with the work of Max Gerson, Bircher-Benner, Ragnar Berg and others who have applied the most recent developments in cytology, histology, and biophysics to the study of food and human requirements. One of the fundamental principles of the author's methods is the health value of a low salt

diet with raw vegetables, and he can quote many famous names of those who have adopted raw vegetables and low salt diets with good results. Keller and his colleagues have had rather few exponents in this country, and nutritional research has therefore not followed the same course. Recently, however, there has been a tendency to devote more attention to a diet utilizing the continental methods of quasi-mineralic vitamins. The author believes that the absence or shortage of some commodities, the rationing of many staple articles, and the search for substitutes will tend to confirm the scientific basis of the dietetic methods which are clearly put forward in this book. The author's object is to show that a cheap and nourishing diet may not only be a decisive weapon in wartime, but a very potent factor, among industrial peoples, in the economic planning and distribution of raw materials that will follow the war.

Material discussed includes: vegetables with additions, the comparative value of foods, the economic side of cheap food, soldier's food and war, milk, sweetening, beverages, and salt and potassium. There is neither bibliography nor index. This little volume should prove of interest and value for the general reader, and for the housewife in particular.

HUMAN PHYSIOLOGY.

By Kenneth Walter. Penguin Books, Harmondsworth, Middlesex, England; Penguin Books, Inc., New York. 25 cents. 7 x 4¼; 127; 1942 (paper).

It is generally recognized that a man equipped with a small amount of knowledge is often in a more dangerous position than one who has no knowledge at all. His information may be just sufficient to allow him to reach erroneous conclusions. In no department of learning is this more likely to be the case than in physiology and in medicine. It was with the full knowledge of this danger that the author undertook the task of writing this elementary work on physiology. He feels that anxiety is the most common symptom displayed in the consulting-room of today, anxiety about health and fear of disease. But even more common than anxiety concerning health is that concerning life itself. In view of all this, the author expresses the ardent hope that in providing his readers with an elementary knowledge of the working of their bodies he will have discouraged rather than aggravated their anxieties. He may well feel proud of his efforts as presented herein, for he states his facts clearly, concisely, and simply; his conclusions are sound. His advice should receive serious consideration.

In order, the author presents his material on the following subjects: the cell, the digestive system, food, the circulatory system, respiration, excretion, the life of movement, the central nervous system, the special senses, chemical messengers, reproduction, and physiological diversion. The book is illustrated with a number of drawings and two plates made from X-rays. There is neither bibliography nor index.

THE WAR ON CANCER.

By Edward Podolsky. Reinhold Publishing Company, New York. $1.75. 7⅞ x 5; 179; 1943.

Cancer continues to be one of the most dreaded and dangerous afflictions of the human race. The campaign against it has been and is being fought on many fronts by surgeons, physicists, biologists, and chemists. The author lucidly describes all these avenues of attack. Can you recognize the warning signs of cancer? Do you know what its causes are now thought to be? Is cancer hereditary? Is a cure for cancer in sight at the present time? Deaths from this dread disease are on the increase. To reduce them, everyone needs to know the answers to these questions. The book discusses the effectiveness of X-ray, cyclotron, radium, surgery, and refrigeration. In addition, it brings up to date the effect of diet, and the very latest advances that science has made in the battle against this modern scourge. Unfortunately, however, a criticism must be made. Although the author does present an impressing array of facts on cancer, he is not always too careful to differentiate between theory and speculation and what is presently accepted as genuine fact. The result is that the average reader, not being familiar with all of the methods whereby the scientific chaff can be separated from the grain, is likely to be unable to see the forest for the trees, and, in consequence, may be slightly confused and worried and may easily be expected to make some misleading, if not actually false, deductions. In spite of this shortcoming, the present book does provide another potent weapon for the war on cancer—public enlightenment. There is no bibliography, but both a name and a subject index are supplied.

MEMOIR OF WALTER REED. *The Yellow-Fever Episode. By Albert E. Truby. Foreword by Jefferson Randolph Kean. Paul B. Hoeber, Inc., New York and London.* 50 cents. 7¾ x 5¼; xiii + 239; 1943.

It is with considerable diffidence that one opens a new book on Walter Reed and yellow fever when there already exist so many books and articles on the question—and so many good ones among them. But one is immediately captivated anew by the greatness of the story and the honest and pleasant way it is told by A E. Truby, Brigadier General, U.S.A., retired. Truby, a first lieutenant in the United States Medical Corps during the Cuban Expedition, happened to be the post surgeon at the post hospital at Columbia Barracks during the fateful months of 1899 and 1900

when the Reed board performed its historical experiments there. Truby knew all the members of the board and the other actors of the drama rather well, and became a personal friend of Walter Reed. He is thus able, relying on his personal memories, official documents, and the testimony of other survivors with whom he got in touch, to give a faithful, detailed, lively account of the rôles of Finley, Lazear, Reed, Caroll, Agramoute and all the others who participated in the great experiment. Some details are brought into focus for the first time. These personal memoirs of General Truby are a most useful and delightful book for the medical man as well as for the layman.

WHAT TO DO TILL THE DOCTOR COMES. *A Home Manual for Emergencies.*

By Donald B. Armstrong with the collaboration of Grace T. Hallock. Simon and Schuster, New York. $1.00. 6½ x 4⅛; 354; 1943.

Knowing what or what not to do in case of emergency can easily make a difference of life or death to the person injured. Every one should be prepared to give intelligent first-aid in peace time as well as in war time.

The present manual is designed particularly for home use. It is not intended to replace the first aid courses given by the Red Cross but rather to supplement them. Because it is written for home consumption it has been possible to include much information about common illnesses as well as accidental injuries and to amplify explanations of all sorts. Various standard procedures are summarized for those who have had first-aid training and wish to refresh their memories quickly.

Part I is concerned with first-aid in general—What to be ready for, what to do, how to get help, what materials to have ready, etc. In Part II, bleeding, shock, asphixia, and chemical poisoning are discussed in some detail. Part III, First-aid from A to Z, consists of an alphabetical arrangement of topics which enables one to find quickly and easily the necessary information in almost any problem that is apt to arise in an emergency situation. Part IV is concerned with war injuries resulting from high explosive bombs, incendiary bombs, and gases.

The book is authoritative and clearly written. It should be quite useful.

HISTORY OF SURGERY.

By Richard A. Leonardo. Froben Press, Inc., New York. $7.50. 9 x 6; xvii + 504 + 100 plates; 1943.

On 413 odd pages the history of surgery all over the world is reported from 10,000 B.C. up to our own day. The organization of the book is such that it constitutes no more than a gigantic historical "Who's Who" of surgeons—Billroth e.g. is dealt with in 12 lines, Larrey in 14 lines—and the basic character of this representation is not changed by the few well chosen quotations from surgical classics. The book is superfluous for reference purposes because such bio-bibliographical histories of medicine already exist. It is more than superfluous because, being a mere compilation, it lacks the grace of style and the personal approach as well as a definite point of view on general historical problems and medical problems in particular which these general histories usually display in spite of their bad organization. The same lack of imagination which characterizes the text is shown in the choice of the illustrations, 50 per cent of which are bookplates. The author has included an extensive and interesting bibliography on the history of surgery and an index.

TRAIL TO LIGHT: *A Biography of Joseph Goldberger.*

By Robert P. Parsons. Bobbs-Merrill Company, Indianapolis. $3.00. 8⅜ x 5⅜; 353; 1943.

Goldberger, admirably presented to us in this book, was a man with great singleness of purpose, and it was this that made him a great scientist, painstaking and scrupulously thorough, and invariably sound in his final judgments. His social feeling dominated his life, urgent social needs determined his fields of work (yellow fever, typhus, dengue, typhoid, measles, diphtheria), and led him, a bacteriologist by training, to undertake his remarkable study of pellagra, whose causes were then quite unknown, and to establish it definitely as a nutritional disease. Concerned as he was with the social function of medical science, and dealing largely with clinical material, he nevertheless spent a considerable amount of time in fundamental laboratory research.

Parsons draws a striking picture of the development and career of a scientist who was truly devoted to medical research and its application.

BIOCHEMISTRY

LABORATORY MANUAL FOR CHEMICAL AND BACTERIAL ANALYSIS OF WATER AND SEWAGE. *Third Edition.*

By Frank R. Theroux, Edward F. Eldridge and W. LeRoy Mallmann. McGraw-Hill Book Company, New York. $3.00. 8 x 5½; x + 274; 1943.

This highly successful laboratory text is here presented in its third edition. The fact that it has gone through three editions in only eight years' time is significant evidence of the high regard in which it is held. The book contains specific directions, in outline form, for making the chemical determinations necessary for the control of water and sewage treatment plants, the analysis of polluted water and the examination of

industrial wastes. Each determination is accompanied by calculation formulas, many of which are numerically illustrated. In addition to the specific directions for the tests, the manual contains methods of sampling, laboratory technique, a discussion of the chemistry involved, interpretation of results and related topics—thus making it more valuable as a general manual for those using the results of water and sewage analysis. A number of new tests and discussions have been added to the chemical sections of the book and extensive changes have been made in the rewriting of the bacteriological section.

In this edition, a new section, dealing with the testing of boiler waters, has been added. The most commonly used tests have been written in the step-by-step form peculiar to this book. The section has been divided into two parts, the first of which deals with tests used in the field or power plant where a minimum of equipment and personnel is available. The second division gives additional procedures for power laboratory testing which require more equipment and more careful manipulation. Additional problems and their answers have been added to the section dealing with the general discussion of chemistry and related topics.

The manual is indexed. Plant chemists, sanitary engineers, those engaged in water and sewage plant operation, teachers and students of water and sewage analysis will find this excellent book a much-needed tool for their work.

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume XII. Edited by James Murray Luck and James H. C. Smith. Annual Reviews, Inc., Stanford University P. O.* $5.00. 8¾ x 6; ix + 704; 1943.

The previous eleven volumes of this *Annual Review* have received such a general and enthusiastic acceptance by workers in many fields of biology and chemistry that a detailed description of this addition to the series appears to be unnecessary. In spite of the many difficulties which wartime conditions impose upon the production of a review of this type, the present volume is a worthy addition to this valuable series.

The 24 papers comprising this volume cover the subjects of Biological oxidations and reductions, Proteolytic enzymes, The steroids ,The chemistry of the proteins and amino acids, The chemistry and metabolism of the compounds of sulfur, Carbohydrate metabolism, Fat metabolism, The metabolism of proteins and amino acids, The chemistry of the carbohydrates, The chemistry of the lipins, Mineral nutrition, The chemistry of the hormones, Water-soluble vitamins, Fat-soluble vitamins, Nutritions (1941 and 1942), Animal pigments, Synthetic drugs, Photosynthesis, Mineral nutrition of plants, Carbon dioxide assimilation in heterotrophic organisms, Biochemistry of microorganisms, The electron microscope in biology, The chemistry of viruses, and Microchemistry.

Each paper represents a concise and authoritative review of recent work in the field covered, and includes an extensive bibliography. There are also author and subject indexes covering the volume as a whole.

BIBLIOGRAPHY OF REFERENCES TO THE LITERATURE ON THE MINOR ELEMENTS AND THEIR RELATION TO PLANT AND ANIMAL NUTRITION: *Fourth Supplement to the Third Edition. Originally compiled by L. G. Willis. Chilean Nitrate Educational Bureau, New York.* Free. 11 x 8½; 92; 1943 (paper).

The growing importance of the *Bibliography of References to the Literature on the Minor Elements* can be seen in literature lists accompanying papers on plant and animal nutrition. The last complete edition of the *Bibliography* (the fourth) was published in 1939. Since then four supplements have been issued (notices of all of these have appeared in earlier numbers of Q. R. B.). The present supplement, the fourth, contains 690 abstracts which include 110 crops and 30 elements. The usefulness of the bibliography is enhanced by the author, element, and botanical indices. A number of elements which previously were classified separately are now grouped under the heading "Rare Earths."

THE UNIVERSITY OF COLORADO STUDIES. *General Series (A). Volume 27, No. 1. Containing* the following papers: *Resuscitation and the Analeptic Drugs; University Research Lecture, 1942,* by Richard W. Whitehead; *Abstracts of Theses and Reports for Higher Degrees, 1942. University of Colorado Bulletin, Volume XLII. General Series No. 501. Library of the University of Colorado, Boulder, Colorado.* $1.00. 10 x 7⅞; 79; 1942 (paper).

THE WEIGHT AND THYROTROPIC HORMONE CONTENT OF THE ANTERIOR PITUITARY OF SWINE. *Research Bulletin 357, Agricultural Experiment Station, University of Missouri. By H. D. Elijah and C. W. Turner. University of Missouri, Columbia, Missouri.* 9 x 6; 27; 1942 (paper).

SEX

SEX IN MARRIAGE. *Third Edition, Revised and Expanded. By Ernest R. Groves and Gladys Hoagland Groves. Illustrations by Robert L. Dickinson. Emerson Books, Inc., New York.* $2.00. 5 x 7⅞; viii + 224; 1943.

The third edition of this well-known volume maintains the previous high standards set by its predecessors.

The normal aspects of sexual relations in married life are simply and honestly discussed. Possible causes for minor maladjustments are exemplified and remedial measures are suggested. Wisely, pathological and neurotic disorders are omitted. The material has been brought up to date to conform with the newer knowledge of sex from the psychological and physiological point of view, and from the modern liberalization of sex in an educational and practical sense. The contents of the book are essentially an abridgment from *Sex Fulfillment in Marriage*, already reviewed in these pages.

BIOMETRY

ELEMENTARY STATISTICAL METHODS.

By Helen M. Walker. Henry Holt and Company, New York. $2.75. 9¼ x 6; xxv + 368; 1943.

This book is designed as a text for a first college course in statistics, and the purpose is to acquaint the student with a variety of statistical techniques, the logic underlying them, the methods of computation, their limitations and powers, and the interpretations to be given them. The emphasis is therefore on descriptive statistics. A second book is promised on statistical inference, and the final chapter in the present volume on sampling is designed to bridge the gap between the two.

The author is very successful in her endeavor. The procedures are explained with great clarity and with a wealth of detail which is helpful to the beginner. At the same time the objectives stand out clearly and certain philosophical issues and underlying principles which affect the interpretation of results are more fully discussed than in most texts. The discussion of the nature of scale (p. 187) is particularly welcome, as it is fundamental to any consideration of the statistics of measurements and yet very often is awarded no critical consideration at all.

The balance between presentation of mechanical detail and of important concepts is achieved partly through sectional subdivisions of the treatment of a given subject. For example, the sixty pages devoted to regression and correlation are grouped into three chapters of about equal length on general concepts, computations, and interpretations, respectively. This has the advantage of isolating the mechanical side of the matter so that it may be given completely without at the same time subordinating the meaning and interpretations. Many of the algebraic proofs and notes are given in appendices.

Although the book is very free of errors, it may be well to call attention to two or three which the reviewer noted, as well as to certain places where the discussion seemed a little limited. In the frequency diagrams (pp. 38 and 39) the ordinate is labeled as frequency instead of frequency per unit of the abscissa, in spite of the fact that in the text the student is warned that it is area and not ordinate which represents frequency. On page 125 it is stated ". . . both variance and standard deviation are expressed in units of the original distribution." Although what the author is pointing out is that they are dimensional, the statement as worded seems to say that they have the same dimension. The discussion of mean deviation and standard deviation (p. 114) implies that it is algebraically unsound to use absolute values, and that the only purpose of squaring deviations is to get rid of sign. In the discussion of the use of symbolism (p. 80), the opening sentence reads "The scientist resorts to symbolism because words often fail to meet his needs for clear, precise, and unambiguous statements." This implies that the symbols are more precise than the words which define them, and this implication is strengthened by the discussion which follows in which it is stressed that "A vague idea, . . . can be conveyed by words, but precise ideas are excessively difficult to achieve without the use of symbolism." This view, that the symbols mean something in themselves apart from the words defining them, may account for the emphasis that is given to the value of standardization of symbols. Although such standardization may make the beginner more readily able to turn from one page of algebra to another, it has the danger that it may lead to the kind of inflexibility that prevents some students from doing a geometry proposition when the letters are changed. The desirability of having symbolism "fit like a straitjacket" (p. 81) is open to debate.

Any good book which deals with such concepts at all will always arouse debate on some issues. This book should, therefore, be a stimulating one to use in the classroom as well as an excellent introduction to the subject for the student who goes it alone.

PUBLIC HEALTH STATISTICS.

By Marguerite F. Hall. Paul B. Hoeber, Inc., New York. $5.50. 9¼ x 6½; xxii + 408; 1942.

Although many elementary statistics texts have been published in the last twenty years, they are for the most part directed at special fields such as education, economics, psychology, or biology. There are only two or three such books addressed to the workers and students in public health. The present book is designed to meet the needs of such workers, but unfortunately it fails to do so not because of the scope of the work but because of the countless errors in its execution. These are not a question of mere looseness of statement, or oversimplification, but are in large part straight errors of fact as to source material, mathematical definitions, and interpretation of statistical constants.

A few examples will suffice to indicate the kind of

erroneous statements characteristic of the book: "The actual application of statistical methods to the study of biological problems began with Sir Francis Galton" (p. 4). "For statistical computation all intervals should be of equal size or width" (p. 41). "The background for the logistic curve is laid in the laws of chance; i.e., in the formula for the normal curve of errors first propounded by Bernoulli" (p. 120). ". . . total births would represent the total number of women exposed to the risk of dying from puerperal causes" (p. 215). "By definition the probable error is that value by which a second measurement is as likely to be more than a first measurement as it may be less than that measurement" (p. 225). "Chance variations are always larger for small samples than for large samples" (p. 226). "It [the average deviation] is a measure computed without regard to sign. Mathematically such a procedure invalidates further use of the constant" (p. 285). ". . . point of inflection or the point at which the curve changes curvature" (p. 287). "The only true measurement in public health statistics is the census and that is made official through the law." (p. 339).

These illustrations are by no means isolated cases of error. They have been selected because they were short statements from a wide variety of subject matter, but the entire discussion of such important topics as life tables, probability, and correlation, contain so many misstatements and misinterpretations that it is impossible to represent them in a short review.

A thorough rewriting of the book is necessary before it could be recommended to a person turning to it for factual information or instruction in method.

STATISTICAL TABLES FOR BIOLOGICAL, AGRICULTURAL, AND MEDICAL RESEARCH. *Second Edition, Revised and Enlarged.*

By Ronald A. Fisher and Frank Yates. Oliver and Boyd, Ltd., London. 13s. 6d. 11¼ x 8¼; viii + 98; 1943.

The first edition of this set of tables published in 1938 proved to be well adapted to the needs of research workers and computers both for the selection of material and convenience of form. This second edition contains four new tables inserted with secondary members so as not to disturb the numbering system of the previous edition. The new tables are numbers V1, V2, VIII1 and VIII2. There is also an extension of Table XVII giving combinational solutions. A list of errata discovered in the first edition is given. The new material adds 8 pages to the previous edition.

Tables V1 and V2 are for use in testing the significance of the difference between two means having different error distributions so that two estimates of variance are required. Table V1 pertains to the distribution of differences compounded of two Student distributions having n_1 and n_2 degrees of freedom respectively. Table V2 deals with the case where the distribution of differences is compounded of a normal distribution of known variance and a Student distribution of n_2 degrees of freedom. The use of the tables is explained and illustrated in the introduction, page 3.

Table VIII1 gives for various levels of probability (P), the upper and lower limits of the probability (π) of a single event when the event has been observed to happen a out of N times.

Table VIII2 facilitates the calculation of density of organisms estimated by the dilution method if the dilution ratio is 2, 4, or 10. An illustration in the introduction explains the procedure for getting both most probable density and fiducial limits for this number.

This second edition with its new material will be welcomed by workers in the field.

THE BULLETIN OF MATHEMATICAL BIOPHYSICS. *Volume 6, Number 1, March, 1944.*

Edited by N. Rashevsky. University of Chicago Press, Chicago.

This number contains the following papers under the general heading "Studies in the Physicomathematical Theory of Organic Form," by N. Rashevsky: Introduction, form of plants; Locomotion and form of snakes; Some general considerations on the shape of quadrupeds; General theory of quadruped locomotion; Loss of energy due to impact of extremity against the ground; Suggestions for an approximation method for solving the equations of motion of a chain of linked levers; Flight of birds and insects in relation to their form; The internal structure of animals; Some remarks on unicellular organisms.

PSYCHOLOGY AND BEHAVIOR

PSYCHOSOMATIC MEDICINE. *The Clinical Application of Psychopathology to General Medical Problems.*

By Edward Weiss and O. Spurgeon English. W. B. Saunders Company, Philadelphia and London. $8.00. 9 x 6; xxiii + 687; 1943.

This is an important book since it is the first complete presentation of the principles in the practice of psychosomatic medicine, defined by the authors as the clinical application of psychopathology to general medical problems. The first two chapters deal with the necessary groundwork in definition of terms and the explanation of what psychosomatic problems actually consist and the theoretical concepts underlying personality development and psychopathology. In the consideration of this latter topic the authors follow the Freudian teaching rather closely. This will

be too dogmatic for some and perhaps not enough for others. The following chapters are concerned with the psychosomatic problems involving various organ systems—cardiovascular, gastro-intestinal, endocrine, metabolic, genito-urinary and sexual, respiratory, central nervous systems, special senses, and some special topics, for example, allergy, dentistry, arthritis. There follow then special chapters on military medicine, general principles of psychotherapy, normal problems in psychotherapy, special therapeutic procedure, and discussion of requisite training in psychosomatic medicine.

The chapter dealing with the actual psychosomatic problems as encountered in connection with various organ systems is extensive, covering the ground rather fully with excellent clinical descriptions and actual case material indicating the problems and how they were managed. It would be manifestly impossible to state in any book all the numerous varieties of problems which are encountered, but the principal topics are well covered. The handling of the material shows a judicious attitude without overemphasis of any certain aspects of the matter, and in every case there is a clear recognition that these problems are problems involving people who suffer in numerous aspects of their living.

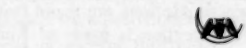
The chapters concerning the genito-urinary system and the sexual function are very well developed with a frank statement concerning normal and more unusual sexual difficulties and their management.

The chapter on military medicine gives a very cogent statement concerning the relation of compensation practice and chronic neurosis. The suggestions concerning the neuropsychiatric contributions at induction centers and reception centers are to the point. The chapters on treatment follow rather closely the Freudian approach, but in general one feels a plasticity in the presentation which is welcome to this reviewer.

The book, being the first of its kind, will find a ready welcome in general medical and psychiatric circles. It is a very pleasant experience to have brought together within a single cover actual case material of such a varied sort, illustrating common problems and how they can be managed. This has not been possible before, but it has been necessary to turn to periodic literature. No text is free of dogmatic statements. This inevitably follows unless the author hedges at so many points that the product suffers from vagueness. Nevertheless it is bothersome to this reviewer to see, for example, the bald statement that neurasthenics suffer from deprivation of affection in childhood. It would be more cautious, but to my mind truer, to say that affectional deprivation has been noted as occurring in some patients who turn out to be neurasthenic. The whole question of what constitutes affectional deprivation is completely up in the air, since the patient's retrospective account of things may differ completely with an account rendered on the spot. It is every psychiatrist's experience to see patients who have erected a completely illusory view of their early lives with their parents just as it is to see parents who have a completely illusory view of their children. Therapeutically there is an opportunity sometimes open in the exposure to patients of the false beliefs they have entertained concerning their parents. This is an opportunity on a par in frequency, I would suspect very strongly, with that offered by connivance with patients in the view that they have been deprived of affection and are attempting to find some late substitution. This, however, is not very important in the final estimate of the worth of the text.

One very annoying thing which should not have been allowed to creep into such a useful and important volume is the use of the noun, "psychopathology", by general consent referring to a branch of science, to mean a diseased or abnormal process. For example, "There is a greater tendency for psychopathology to begin early in personality growth than for tissue pathology to begin early in physical growth." This abuse of the terms pathology and psychopathology is common enough, but should not be encouraged by inclusion in a volume so important for precise understanding of our common problems.

The book is the result of collaboration between the professors of medicine and psychiatry at Temple University, and this arrangement would seem to set the necessary stage for any similar publications to follow. Certainly any psychiatrist who wanted to write such a text would be bound to have at his disposal the constant collaboration of an internist with working knowledge from a practical angle of psychosomatic problems.



THE LIFE OF THE ROBIN.

By David Lack. H. F. and G. Witherby, Ltd., London. 7s. 6d. 6¾ x 4¾; 200; 1943.

Although the English robin may be considered as familiar a bird as any to a nation of nature-loving people, yet the average person would be surprised at the dearth of facts that are known concerning its habits and behavior. One reason for this lack of knowledge may be ascribed to identically appearing sexes, but the main cause resides in the fact that methodical and painstaking continuous observations are seldom made on a single species. Hence it is only now that the significance of the robin's activities are becoming apparent.

In this fine study the author demonstrates that the rôle of singing by the male is to announce ownership of territory and to advertise for a mate, facts well-known to modern ornithologists. By means of colored bands, it was discovered that pair formation occurs in December, over three months before nesting. Singing and posturing accompanies the mate selection, which is always made by the female, but no evidence has been found to indicate any reason for her choice. Pairing is not necessarily maintained for life.

Courtship is distinct from pairing and occurs only during nest-building activities. At this period the female need only remain still, and this immobility acts as a releaser or signal to cause the male to mount. Following coition, courtship continues on a more elaborate scale, a post-nuptial or bond-forming display during which the cock feeds the hen apparently keeping the pair united.

In discussing the significance of territory the author argues against the beliefs that territories assure an ample food supply for the owners and their family, or that they may tend to regulate population density. It is suggested that the revival of spring behavior in autumn is due to a change in physiological state that may in some way be connected with the inhibition to migrate.

Experiments with a stuffed bird demonstrated that the attack behavior is elicited by three separate signals: flying-in-pursuit by the sight of a small bird flying away, threat display by the sight of red breast feathers, striking by an object the shape of a robin. This cause and effect is not firmly fixed and may vary under different circumstances both internal and external. Many more interesting features of the robin's life might be discussed, but it must suffice to state that the problems of migration (practically limited to the females), the mortality and life expectancy of a robin population, and the activities around the nest are other phases in the bird's existence that were studied. The book closes with a discussion on instinct with reference to bird behavior.

This little volume is well documented with references given at the end. Although citations are made from studies on other birds, no mention is made of Kendeigh's work on the house wren which in many ways is quite comparable. Several photographs show the posturing of the robin for the first time.

A Social Psychology of War and Peace.

By Mark A. May. Yale University Press, New Haven; Oxford University Press, London. $2.75. 9 x 6; viii + 281; 1943.

This book reminds one of the story of the man who excused the leak in his roof on the ground that when it was raining he couldn't repair the leak, and when it wasn't raining he didn't need to. It is impossible, for obvious reasons, to publish a satisfactory analysis of the factors that make war inevitable while a world war is going on, and in time of peace it is not necessary.

That at least part of the present study was carried out during the progress of the current war is shown by the documentation, which includes works published in 1943. The reviewer would not advocate omission of any consideration of literature published during the war, nor would he discourage attempts to make serious studies of war during wartime but he would point out that the publication of results of such studies before the fires of hatred and suspicion have cooled involves certain political amenities which the author must observe in order to save his skin.

In the present work the author states that when a war ends with the peace terms imposed by the victor on the victim under duress another war becomes sooner or later inevitable, since the defeated nation will at once begin planning revenge and anticipating the day when such revenge may be realized. But on a later page he states that a peace is more likely to be lasting if it can be imposed against the will of the defeated people, since in that case the victim will be unable, and the victor unwilling, to disturb the peace.

The intelligent reader, even though unable to reconcile these diametrically opposed statements, can at least understand the underlying circumstances that caused them to be written. But the reader who cannot read between the lines is likely to profit but little from the perusal of this book.

Some day the war now being contested will be over, and the construction of peace will begin anew. Swords and spears will be reconverted to ploughshares and pruning hooks, and Sisyphus will once more undertake to roll his rock to the summit of the hill from which it has been rushing down so precipitately. When such time comes a pair of alternatives will confront us. On the one hand we can let the peace grow of its own accord, like Topsy, only to have it collapse just as it did before. On the other hand, we can prepare ourselves by study of just such works as this to set up a just and durable peace and so take away the occasion for war.

The Expression of Personality. *Experimental Depth Psychology.*

By Werner Wolff. Harper and Brothers, New York and London. $3.50. 8½ x 5⅝; xiv + 334; 1943.

This is a report in one volume of the work carried on by the author since 1925 in laboratories in Berlin, Barcelona, and in the United States. It deals with a series of experiments in the expression of personality with an attempt to coordinate the useful concepts and methods from *Gestalt* psychology and psychoanalysis. What Wolff has tried to do essentially is to seek a delineation of those expressions of personality which are apt to be consistent and less variable than verbal expressions are inclined to be. For this purpose he has studied facial expression, general bodily movement, handwritings, records of voice, judgment of the profile and of the hands, etc. The material was carefully handled in order to get a concensus of opinion concerning these factors for each subject, and this was compared with the self-evaluation. Concensus was fairly readily achieved in the sense that summarizing descriptions were easily yielded from the various descrip-

tions at the hands of several observers. The astonishing and important thing is the difference between the objective account of a given subject from the subject's own account of himself, both when he was aware that he was speaking of himself and when he wasn't aware of it. The oustanding thing was that when the subject was describing himself, even when he was unaware of it, he used a different kind of language than when he was describing someone else, a language rich in emotional terms. This held true either when giving himself a more positive or a more negative description than other observers gave. According to the author this taps the hidden dynamic factors in the personality.

The author has attempted to assess the intrapersonal tendencies by the construction of what he calls a crossroad test, divided into a crossroad memory test, crossroad perception test, crossroad decision test, crossroad color matching test. These constitute only different ways of getting at the vital elements in the intrapersonal tendencies, and furnish in actual practice a certain focussing of these tendencies so that personality description may be read off with reasonable validity.

The book is full of ingenious test methods according to the *Gestalt* system. The author's conclusion that he has developed the beginning of an experimental depth psychology rests on the analogy between the inhibitory effects upon the memory of a subject when he perceives and recognizes his own functioning and the inhibitory effects on the verbal expression as noted in the Jung test, for example. This estimate of the author's concerning his own work would appear to have considerable merit and to furnish one of the few bridges existing between the subjective psychoanalytic method and traditional methods of experimental psychology. As such the author's work is a very important one, and one can subscribe fully to the enthusiasm expressed by the editor, Gardner Murphy.

CULTURAL AND RACIAL VARIATIONS IN PATTERNS OF INTELLECT: *Performance of Negro and White Criminals on the Bellevue Adult Intelligence Scale.*

By Solomon Machover. Bureau of Publications, Teachers College, Columbia University, New York. $1.60. 9 x 6; 91; 1943.

This book attempts an answer to the following questions·

1. Are Negro criminal groups, widely divergent in cultural background, but equated in age and in a suitable measure of general capacity, differentiable in the patterning of subtest abilities on the Bellevue Adult Intelligence Scale?

2. Are White and Negro criminal groups, matched in age, education, and IQ for the scale as a whole, differentiable in the patterning of subtest abilities on the Bellevue Adult Intelligence Scale?

3. Are native White criminal and non-criminal groups matched in age, education, and IQ for the scale as a whole differentiable with respect to the patterning of subtest abilities on the Bellevue Adult Intelligence Scale?

The test methods were carried out on 425 male adults, the group being selected with the hope of bringing to bear factors which would help in the answering of these three questions. Particularly important was the selection of groups from the divergent cultural backgrounds.

Some of the conclusions from the examinations follow:

1. A significant differentiation was obtained in each of the two-group comparisons.

2. A given variation in developmental background exerts an influence which, either in addition to or quite apart from any effect on the IQ, is more or less specific to different mental functions, so that a relatively distinctive qualitative pattern of ability results.

3. The subtest pattern of culturally very restricted southern Negroes runs counter to expectations based on the assumption that performance tests are less culture-bound than abstract verbal tests. The southern Negroes did better than the northern Negroes in verbal comprehension and similarities, and worse in performance digit symbol, block design, and picture arrangement....

Southern Negroes show marked defects in perceptual organization and in perceptuo-motor integration.

The test pattern associated with marked cultural restriction is similar to patterns which differentiate normals from individuals showing pathological impairment of mental functioning.

The subtests which criminals handle relatively well are among those in which pathological dysfunction is frequently manifest, while those which they handle relatively poorly often stand up well in psychopathological conditions.

The author had at his disposal the criminal population of the Psychiatric Clinic of the Court of General Sessions and of the Bellevue Psychiatric Hospital.

BORDERLANDS OF PSYCHIATRY.

By Stanley Cobb. Harvard University Press, Cambridge. $2.50. 9 x 5¾; xiv + 166; 1943.

This is another little book following on the author's *Foundations of Neuropsychiatry*, which might be called a further statement of Stanley Cobb's personal credo in regard to the body and mind question and its manifestations in certain special aspects of human functioning which from time immemorial have come to the attention of physicians, neurologists, and psychiatrists.

The chapter headings will indicate what these special areas of interest are:

1. Body and mind.
2. The parallel evolution of speech, vision, and intellect.
3. Speech and language defects.
4. The function of the frontal areas of the human brain.
5. The anatomical basis of the emotions.
6. Consciousness.
7. Concerning fits.
8. Psychoneurosis.
9. Psychosomatics.

As in his previous book nothing is lost in the presentation of the material by the intrusion in numerous places of the author's own views of the field in question, and this can only be attributed to his breadth of vision and his capacity for recognizing false problems and getting to the kernel of what the real problem consists. His breadth of vision is everywhere seen in his call for all-over investigation of all the phenomena concerned with any one of these special items, and he never in any case lets himself go all out for a special theory. In the present state of things, and perhaps in the very nature of things, this is the best view to take of the matter.

This book is an outgrowth of a series of lectures given for the Lowell Institute in 1940, and the author disclaims any intention of presenting it as a textbook or a monograph. Nevertheless the material is so attractively presented and so simply put that medical students and physicians in general could very well profit from the teaching which is contained between its covers. The volume lives up to the expectation from its author of simplicity and clarity of presentation, without these factors doing violence to the known facts.

MATERNAL OVERPROTECTION.
By David M. Levy. Columbia University Press, New York. $4.50. 9 x 6; ix + 417; 1943.

This is a summary of the case material at the Institute for Child Guidance, New York City, concerning those children and their mothers in which there has been a flagrant display of oversolicitude, overprotection. The result of this in the child is a process of infantilization and prevention of social maturity and leads to one of two things, either the child remains childish and at the submissive beck and call of his mother's domination, or he indulges in tantrums of one sort or another expressive of his own desire to dominate the situation, and his mother dances to the tune he pipes with abject subservience. The astonishing thing about the treatment of this situation is that whereas not infrequently the children outgrew the stunting effect of the maternal overprotection, the mothers never changed and remained to the end plainly unaware of their part in the development. The book is an excellent presentation, thoroughly well documented with excellent summaries of case material.

As one might expect in these homes with dominant mothers whose entire investment is in the children, the husbands play an exceedingly minor rôle, and appear to be of the retiring, kindly, generous sort who make no particular impression in the situation. The author remarks that there are instances also of paternal overprotection in which the situation is reversed. He postulates, or at least gives some consideration to the fact that the final determinant in the situation may rest on a hormonal basis in which one deals with an excess of a kind of behavior in the female common to all in less exaggerated proportions.

Less helpful is the insistence on such a debatable psychoanalytic concept as the Freudian penis envy ascribed to the female. Actually what good the author gets out of this hypothesis when he himself admits that it has been seriously challenged by numerous workers is hard to see. In fact his insistence throughout that the psychoanalytically trained worker is in a favored position to understand the problem of maternal overprotection, to this reviewer's way of looking at things, expresses only the author's own psychoanalytic bias. There is nothing in the actual factual case material which could not be completely adequately stated in non-psychoanalytic terms, and make just as good and favorable an argument.

It is an interesting statement of a special problem, and the presentation is lucid and stimulating.

FAMILY SITUATIONS. *An Introduction to the Study of Child Behavior. By James H. S. Bossard and Eleanor S. Boll. University of Pennsylvania Press, Philadelphia.* $3.00. 9 x 5¾; ix + 265; 1943.

The authors have divided this book into three parts entitled respectively. "The situational approach," "Studies of family situations," and "Division of labor."

The first section consists of the historical factors contributing to the development of the situational approach. Throughout, the need of the social sciences for an adequate definition of terms is emphasized. An analysis of different family situations, "segments of life to which the organism reacts as a whole," is presented quite in detail as is also the classification of situations in the family, i.e. socio-economic status, treatment by parents, person-to-person relationships, etc.

Part two is an effort to summarize and synthesize the many specific studies in family situations already made. It is a presentation in tabular and narrative form of a survey of the studies made on family life, parent-child relations, etc. between 1926 and 1940.

Part three entitled, Division of labor, which is a plea for sociologists to accept the situational approach,

seems to place too much emphasis on the situation as a static entity with insufficient consideration of its causes. The authors also designate the family as the particular domain of sociology. ". . . . the analysis of the structure, process and cultural content of social situations in general and of family situations in particular, is the peculiarly appropriate province of the sociologist."

Due to the nature of part two, this book draws heavily on other literature in the field and the bibliography consequently represents most of the major studies either on or related to the family. In general this work tends toward conventionality and leaves doubt in the readers mind as to the value of new discoveries and theories. It adds little that is new to the field of family studies, but is of value as a summary and an interpretation of existing literature.

MANAGING YOUR MIND. *You Can Change Human Nature.*

By S. H. Kraines and E. S. Thetford. The Macmillan Company, New York. $2.75. 8¾ x 5½; viii + 374; 1943.

The authors of *Managing Your Mind* have created an interesting guide for peaceful, productive living. The thesis of the book centers around two major ideas. (1) The stresses and tensions developing from the strain of living in the modern world, and (2) Prevention and remedy of those tensions by a rational pattern of living.

Neurotic tendencies are taken up in order of the parts of the body involved, e.g., heart, stomach, sense organs, etc. Through the entire presentation runs an account of the fundamental physiological and psychological mechanisms involved in the abnormality. The frank approach coupled with illuminating case histories leads the reader to believe that the "golden mean" of psychological adjustment is obtainable through reasoning and common sense.

The chapters on Intellectual objectivity and Emotional stability, Achieving maturity, and Psychological mechanisms appear to be intelligent yardsticks for twentieth century living by expressing "the advantages and responsibilities of being a member of society" as well as presenting concrete means of achieving the required stability.

Writing for popular consumption, the authors stress by means of examples and argument, a logical approach to the many adjustments required in the process of living whether it pertain to the delicate parent-child relationship or the more general matter of tolerance toward one's fellows.

It is a stimulating non-technical account of man's ability to control and direct his thoughts and actions. It should prove worthwhile to those who find their mental adjustment to wartime strains difficult. The material in the book is made readily available by the index and chapter summaries.

STUTTERING: *Significant Theories and Therapies.*

By Eugene F. Hahn. Foreword by Sara Stinchfield Hawk. Stanford University Press, Stanford P. O. $2.00. 8¼ x 5½; x + 177; 1943.

This book is a compendium of the significant theories and therapies concerning stuttering. The material is grouped under the headings of the principal workers in the field, both in this country and abroad. This kind of treatment of the material gives the reader a very good grasp of how the subject is dealt with in the hands of these experts, but necessarily results in a great deal of overlap and redundancy. As far as the actual content is concerned it shows that there is every shade of opinion held in the theory and in the practice concerning stuttering from the out-and-out psychoanalytic views of Coriat, for example, to the rather mechanistic views of Knight Dunlap and Lee Edward Travis. It would be rather distressing to a victim of stuttering, for example, to read the serial advice for therapy in this book. Such a victim would come out of it with his head in a whirl as to what is the thing to do. What it amounts to is that eclecticism is the only way to deal with the problem at this time, with speech training and relaxation exercises, suggestion and mental hygiene all involved more or less in the manner of the treatment as carried out under Meyer Solomon. One may gather from reading the material that American authorities have a somewhat more refreshing and broad view of the matter than most of the European authorities cited.

There is an appendix in the volume concerned with procedures in a clinic for stutterers, showing actual case material and how it was managed, with some items of research and a bibliography. It is a valuable and helpful book to those interested in the subject.

YOUR CHILD, HIS FAMILY AND FRIENDS.

By Frances Bruce Strain. D. Appleton-Century Company, New York. $2.00. 7¾ x 5; xi + 210; 1943.

The rich and abundant experiences of the author, both as a mother and as a teacher and councilor in the field of child behavior, have well qualified her for writing this sound and enlightening volume.

Quite logically, the discussions begin with the child in his earliest home environment, showing his reactions to his parents as well as to other members of his immediate family, and carry him through his experiences in becoming acquainted with a constantly broadening environment, and an ever widening circle of personali-

ties (playmates, teachers, doctors, dentists, barbers, milk-men, ice-men, etc.).

The fundamental principles of child behavior and psychology, which the author has expressed so quaintly and simply, are basically sound. Emphasis is always placed on preventive, rather than corrective measures in molding desirable habits, and upon active child participation, rather than complete dominance of parental authority, in the resolution of behavior difficulties. In the correction of bad habits or undesirable behavior reactions, the author recommends a thorough analysis and a complete understanding of the underlying causes of the situation (with the aid of a physician, or psychological advisor, if necessary) for the basis of reform, rather than the trial and error methods of punishment, coersive prevention, or the institution of a substitute habit which may eventually prove as undesirable as the original.

The book will be of exceptional interest and value not only for parents, kindergarten and early grade school teachers, but to all who are interested in the welfare, and the well-being of the young child. The work is profusely sprinkled with illustrative anecdotes from real life, and carries several well-selected photographs of children in natural activities and behavior situations. An index is provided.

RACE AND CRIME.

By William Adriaan Bonger. Translated from the Dutch by Margaret Mathews Hordyk. Columbia University Press, New York. $1.50. 7¾ x 5¼; xi + 130; 1943.

This little volume from the distinguished criminologist of the University of Amsterdam who died in May, 1940, is a magnificent statement in refutation of much prejudice attempting to link criminality with certain races. The implication of such prejudices of course is that the races occupy various levels of desirability, and tacking criminality on to any one race is a favorite method of expressing a certain kind of snobbery. Bonger's book strips all such prejudices, from the current Nazi edition through all other previous editions, of any hint whatever of scientific respectability. He shows the complete lack of any reliable information to support such views, and in contrast to this he shows in the clearest fashion that criminality as a phenomenon is a matter of culture and environmental factors in which constitution, either individual or racial, can have no greater consequence than that of the latent seedbed. Without the plantings from culture and social influences in general, there would never be any harvest of criminals.

The gist of the whole thing is that criminality is not a definable abstruse item. It is only in the study of criminals that one can arrive at any proper understanding of the subject.

In this, his last book, translated fortunately into English, he stands along with the best American tradition in the field. The book is very readable, the translation is excellent, and it may be recommended to any person interested in sociological material.

EMOTION IN MAN AND ANIMALS. *Its Nature and Relation to Attitude and Motive.*

By Paul Thomas Young. John Wiley and Sons, New York; Chapman and Hall, London. $4.00. 9 x 5¾; xiii + 422; 1943.

This book, designed as a textbook for college use in psychology courses, presents an excellent statement of all the current material dealing with the nature of emotions in man and animals. The chapter headings will indicate the nature of the material: The nature of emotion; Attitudes and motives, determinants of emotion; Needs and appetites, the basis of the affective life; Emotional development; Bodily changes in emotion; Patterns of organic response in emotional excitement; Feeling and emotion as conscious processes; Direct determinants of emotion; Predisposing conditions of emotional disturbance; Attitudes and motives in relation to emotion. Each chapter is well presented and has a conclusion which summarizes the material of that chapter. The material is attractively stated, is comprehensive in scope, and is well fortified with references which cover every aspect of the subject.

The book can be thoroughly recommended as a lucid, informative statement of all that is known to date concerning the physiology and psychology of emotional states. One may not finally agree with the author's definition of emotion as a *disturbed* psychological state, and still be grateful that the evidence both for and against his view of the matter is carefully presented in no arbitrary manner.

PSYCHOLOGY OF EFFICIENCY. *A Discussion of the Hygiene of Mental Work.*

By Arthur G. Bills. Harper and Brothers, New York and London. $2.75. 7¾ x 5⅛; xiv + 361; 1943.

Efficiency is defined as "accomplishing the most with the least effort or resources". This book shows how to achieve efficiency through the understanding of those things which hinder it, and by the constructive use of the assets. Some chapter headings indicate its scope: Mental work and mental fatigue; General and specific fatigue; Rest and recovery from mental work; Sleep: its nature and control; Motives and incentives in work; Friction and lubrication; Physical conditions of efficiency; The effect of age changes on efficiency; Self-appraisal and self-improvement; Organization and planning; Effective thinking.

The book is full of valuable information, much of it

from experimental sources, concerning the objectively observable data of normal behavior, and will prove useful to students of psychology and as a background for psychiatry.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE LETTERS OF JOHN MCLOUGHLIN *from Fort Vancouver to the Governor and Committee. First Series*, 1825–38.

Edited by E. E. Rich with an Introduction by W. Kaye Lamb. The Champlain Society, Toronto. Not for sale; issued only to members of the Champlain Society. 9¾ x 6½; cxxviii + 374 + 1 folding map; 1941.

When the Louisiana purchase was consummated the western boundary of the United States was pushed out to the Rockies. Beyond them was a vast *terra incognita*, claimed by the British by virtue of Alexander Mackenzie's transcontinental expedition down the Thompson and Fraser rivers to the Pacific. This was accomplished just thirteen years before Lewis and Clark duplicated the feat by way of the river which they and their Indian guides called the Oregon, but which today is known by the name which the Canadian pathfinders gave it—the Columbia.

It was potentially a region of great wealth, this territory of British Columbia, extending from the Spanish missions on San Francisco Bay to the Russian outpost at the mouth of the Stikine river. Great herds of sea otter basked on its beaches, and innumerable families of beaver erected their dams and lodges on its inland waters. The natives were friendly, and were always ready to barter pelts for fire arms and fire-water—an arrangement that was eminently satisfactory to the British traders whose temperament was such that they preferred to acquire their pelts in this way rather than by penetrating to the interior and by maintaining their own trap lines.

But when the American trappers began to percolate across the Rockies a different situation developed. The Americans preferred to do their own trapping. They saw no need to cultivate the friendship of the Indians. Violence was frequently resorted to, which provoked retaliatory violence, culminating in the martyrdom of the pioneer missionary Marcus Whitman.

To complete matters further, the treaty by which the boundary between the United States and Canada had been fixed did not apply to Columbia. For ten years an honest attempt was made by the two governments to administer this no-man's-land equally, each endeavoring to recognize the rights of the other without forfeiting its own, but the experiment did not lead to satisfactory results. The situation was not helped by the arrogance of the Americans who acted as if they already owned all British Columbia in fee simple.

During this period British Columbia was governed by Sir George Simpson, whose fame in this country derives chiefly from a diplomatic mission to Monterey which he headed during the ascendency of the Mexican Republic, and from his connection with the ill-fated search for the northwest passage by Sir John Franklin. He is remembered in Canada as one of the wisest and ablest statesmen which that nation has yet produced.

Sir George Simpson's domain included also the territory which lay north of Columbia and overlapped the Russian claims, and which was known as New Caledonia—a name obviously due to the large number of Dugalds and Douglasses, McKenzies and McDonalds, McPhersons and McTavishes, among its settlers. These were sufficiently numerous to induce speculation as to whether the choice of sides made by Canada in 1776 and again in 1812 might not be accounted by the concentration of Scotch settlers in the northern provinces.

Travelling was difficult in those days, and Simpson's duties required him to spend much of his time in York, as Toronto was formerly known, so that most of the responsibility for maintaining order in British Columbia rested on the shoulders of John McLoughlin, M.D., the chief factor of the Hudson Bay Company, who owed his appointment to Simpson. McLoughlin had formerly been an official of the rival Northwest Company which had sponsored the Mackenzie expedition, but it is not likely that this dual allegiance had anything to do with the eventual rupture of his friendship with Simpson and his removal from the office of factor. Rather this seems to have grown partly out of his inability to get along with incompetent personnel sent out to him from London, who seem to have been selected not on the basis of efficiency so much as to satisfy political obligations, and partly out of McLoughlin's growing distrust of the authorities who failed to send him the supplies and equipment which he needed in order to perform the various duties of his office.

The story of McLoughlin's thirteen years of service is well told in this collection of his letters written from Fort Vancouver. (Incidentally, the site of this fort is the modern town of Vancouver opposite the mouth of the Willamette River, and not the city of the same name on the Canadian seacoast.) The historic background is supplied by an able introduction from the pens of W. Kaye Lamb and Burt Brown Baker, of the Universities of British Columbia and Oregon, respectively.

One should not put the volume down without congratulating the Champlain Society on the general appearance of this work. Printed on a high grade of paper with artistic type and good binding, and provided with maps and an appendix of biographical sketches of the characters that figure in the narrative, it is everything that a book should be. Those who read it will be glad to note that the Champlain Society has announced the publication of a sequel containing the

letters written by McLoughlin during the eight years he was serving the Hudson Bay company in London.

THE LAW OF CIVILIZATION AND DECAY: *An Essay on History.*

By Brooks Adams, with an Introduction by Charles A. Beard. Alfred A. Knopf, New York. $3.50. 8¾ x 5¾; [349] + [xi]; 1943.

This is not a new book. It is a reprint of a work first published nearly half a century ago. The occasion for its reprinting at the present time is the recent publication in the Atlantic Monthly of a critical essay by Charles A. Beard dealing with the author, Brooks Adams.

The text of *The Law of Civilization and Decay* is here reproduced exactly as in the earlier edition, together with the interpretative essay, which serves as an introduction, but the essay has been greatly expanded beyond its original size, the result of Beard's recent access to some unpublished correspondence between Brooks Adams and his brother Henry. This expansion of the introduction is the only hitherto unpublished material in the volume, and because it is unavailable elsewhere it constitutes the most significant element in the book. To it Adams' original work is affixed as a virtual appendix. In this case it must be confessed that the tail wags the dog very vigorously, since Adams' work is really a masterpiece, and he would hardly have merited such a scholarly appreciation as Beard has written had his own book not appeared first. The converse is not true; the importance of *The Law of Civilization and Decay* is entirely independent of any critical or literary appraisal of its author, just as our enjoyment of a Beethoven symphony or a Chopin fantasy is independent of our knowledge that Beethoven was deaf or that Chopin was tubercular.

For the reader who may have been misled by the title of this work to expect a philosophical treatise similar to Albert Schweitzer's *The Decay of Civilization* a surprise is in store. The political history of European civilization has been written many times, but Adams' work is history written from the standpoint of economics, in which the author takes delight in bringing the reader face to face with personages who have received an undeserved neglect at the hands of other historians and who are quite unknown to the average reader, but who have exerted considerable influence on the world's economic development. Prominent among these is Henry Dandolo, Doge of Venice, ninety-five years old and blind, who lived during the ascendency of Innocent III, the pope who exercised more temporal power than did any other occupant of the throne of St. Peter, either before or since. Innocent had practically every monarch in Europe eating out of his hand, and even John Lackland tried to hand England over to him in fief.

In those days the Venetians were the world's greatest merchants; they took no interest in the intellectual activities of Florence or in the religious activities of Rome, although both of those cities were nearby. But the mercantile activities of the Eastern Empire, although relatively remote geographically, did constitute a real threat to the supremacy of Venice, until Henry Dandolo succeeded in diverting the army which Innocent had sent on a crusade to Palestine, to a campaign against Constantinople. In this venture Dandolo was successful, and the decadence of the Eastern Empire dates from the defeat inflicted upon it by the papal army. Naturally Innocent was furious, and excommunicated every one of the deserters, but was unable to retaliate against Dandolo, who from his security on the Adriatic continued to thumb his nose at the Vatican. The mercantile supremacy of Venice remained unchallenged until the time of Prince Henry the Navigator.

The reader will be impressed to learn that when the present incumbent of the White House introduced the fifty-nine cent dollar he was doing nothing new; the device of tampering with the metallic content of the coinage was not always the result of "coin clipping" by the ruler to replenish his depleted coffers, but was actually resorted to in order to stabilize currency and avoid depressions, and those who authorized it generally understood what they were doing.

Of course, the entire purpose of Adams' work was to enable students of economics to illumine their prognostications in the light of the past, and in this he has been eminently successful. To report in detail the way in which economic history repeats itself would be to expand unduly this review. Suffice it to say that the republication of this classic, which merits wide circulation, is very timely in view of the multitude of economic crises now hanging like the sword of Damocles, ready to drop immediately upon cessation of hostilities.

TWENTIETH CENTURY PHILOSOPHY. *Living Schools of Thought.*

Edited by Dagobert D. Runes. Philosophical Library, New York. $5.00. 8½ x 5½; 571; 1943.

Before entering upon an appraisal of the work now under discussion an explanation is due the reader who may feel inclined to ask why a book dealing with philosophy should receive any notice at all in a periodical devoted to science. The only method of apprehending truth is the scientific method. The philosopher who is interested in the search for truth may adopt this method and himself become a scientist, or he may seek some royal road and so doom his search to failure. But the search for truth should not be the primary concern of the philosopher; his attitude should be that one embodied in the motto of the oldest Greek letter honor

fraternity—"Philosophy is the Guide of Life." If to the scientist truth is something to be pursued and won by the sweat of the brow, to the philosopher it is something by which life may be regulated.

Throughout history the increase of complexity of human life has always been so rapid that its regulation has consistently demanded more than the scientist has been able to tell us, and it has been necessary for the philosopher to indulge in considerable speculation as to what might lie beyond the ever widening frontier of knowledge. This does not mean that as the scientist pushes back the frontier into the unsurveyed wilderness he is curtailing the field of legitimate philosophical speculation. After all, the frontier is only the contact between what is known and what is not yet known, and as it recedes the area of contact increases. For every old question that science answers it asks a dozen new ones, and the ground which scientific research takes away from under the feet of philosophy is restored tenfold.

The scientist who discovers a new truth of nature first summarizes it in a theory and then constructs an experimental set-up in his laboratory to answer the question "Is it true?" On the other hand, the philosopher is likely to establish his judgement as to the validity on a somewhat different foundation—he is likely to enquire "Will its acceptance help me to lead a better life?"

Such a mental attitude characterizes a type of philosophic thought, of which William James is the most eminent representative, though not the founder, known as Pragmatism. Strictly speaking pragmatism is not a school of philosophy, for schools are distinguished by what they believe, rather than by why they believe as they do. We should reasonably expect to find pragmatists in every school of philosophy, and we should expect pragmatism to be immortal, while the schools are

> Like bubbles on the sea of matter born,
> That rise and break, and to the sea return.

For this reason the essay on pragmatism by John Dewey appears to be the most vitally significant among the twenty-two that comprise this work. The others, despite the scholarly manner in which they have been conceived and constructed, seem more concerned with the perishable thoughts of past and present philosophers than with the more enduring features of philosophy itself, and one of them, that by Wing-tsit Chan, is really a historical rather than a philosophical treatise.

Among those who have contributed to this symposium are many of the leaders of modern philosophic thought—Douglas Mackintosh, Alfred N. Whitehead, Bertrand Russell, George Santayana, William P. Montague, Roscoe Pound, to mention a few of the best known. Each essay is well documented and supplied with an extensive bibliography. Unfortunately the book as a whole has two negative defects. First the lack of an index seriously impairs its usefulness to anyone seeking an intelligent knowledge of comparative philosophy, and second, the complete absence of any reference to the works of Rufus M. Jones, whom many students would place in the front rank of contributors to contemporary philosophical thought.

THE NATURE AND PROPERTIES OF SOILS. *A College Text of Edaphology. Fourth Edition, Revised.* *By T. Lyttleton Lyon and Harry O. Buckman. The Macmillan Company, New York.* $3.50. 9¼ x 6⅛; xi + 499; 1943.

This fourth, most recent edition, the first to appear since the death of the senior author, Professor Lyon, embodies some changes, chiefly greater emphasis on the physics of soil moisture, the origin and classification of soils, and the nature of the colloidal condition; additions which reflect investigational advances in these fields in recent years. The volume, like its predecessors, maintains its place as one of the most complete, authoritative and valuable treatments of this fundamental subject of the soil.

Its point of view is that of the edaphologist, considering the soil as the basic stuff from which originate plant and animal food and the fundamental natural resources of materials for industry and life. Yet there is much of a pedological nature on the origin, characteristics, and classification of soil as a geologic entity.

Beginning with an introductory chapter on the origin and nature of soils, the author then considers the nutrients available for plants and the physical properties of soils, and in a very informative chapter discusses the nature and significance of the inorganic soil colloids, after which discussions of the living organisms and of the organic matter in soils follow in natural sequence.

Soil water in its energy relations, movements, relations to plants, to run-off, and to erosion, as well as to drainage, weeds, and evaporation, is covered in Chapters 7 through 10 in a very complete and effective treatment of nearly 100 pages.

Chapters on the origin, nature, and classification of soil materials and on soil formation and types are primarily from the geological or pedological point of view, yet the final consummation of these in soil surveys shows their practical value for agricultural research, for appraisal and evaluation of land, and for sociological and population studies.

The chapter on soil reaction is a very valuable one in its presentation of the fundamental principles involved and its practical suggestions for controlling acidity or alkalinity. Similarly the discussion of lime in its relationship to the soil and to the plant is sound in its fundamentals and practical in its applications,

while the discussion of the nature and utilization of organic soils, especially peat, is excellent.

The four final chapters, concerned with fertility, very effectively cover such important aspects as the nitrogen cycle with its two main divisions of activity, fertilizers and their effect, the practical and theoretical aspects of manuring, and the general questions of the securing and maintaining of fertility in soils. Very complete indices, both to authors and to subjects, enhance the workability of the book.

Valuable from every point of view, this book, already proved and accepted in previous editions, will continue to fill a much felt want for those in the many diverse fields of agriculture, biology, and geology.

THE MICROSCOPE AND ITS USE.

By F. J. Muñoz in collaboration with Harry A. Charipper. Chemical Publishing Company, New York. $2.50. 8½ x 5½; xii + 334; 1943.

We could all agree that in order to obtain the best results with a microscope it is necessary to use it properly. Yet, it is surprising how few people, even scientists, have become really proficient enough in the use of this truly marvellous instrument to profit from its various possible adjustments and the perfection of its optics and general workmanship. There has been a long felt need for a practical manual or guide to the use and care of simple and specialized microscopes and their varied attachments and to the understanding of certain necessary optical principles. The present volume is a very satisfactory attempt to answer this need.

After an introductory chapter on the evolution of the microscope a full description is given of the modern compound microscope. Each part of the optical train is described and diagramed, its purpose and use explained. We are given practical advice as to what oculars to use with what objectives, when and how to use oil immersion, objectives, etc. as well as precise information about numerical aperture, resolution and magnification. The important subject of illumination, to which surprisingly little attention is paid by the majority of people using microscopes, is treated in some detail. We are told how to obtain and use the three usual illumination methods, namely (a) an approximation to critical illumination, (b) critical illumination, (c) Köhler illumination. Dark field illumination is also considered. A very helpful chapter on the use and care of the microscope includes general information on the preparation of materials for microscopic study. An actual step-by-step example is given of the proper use of a compound microscope to examine a specimen. In a later chapter a list of common errors in the use of the microscope is submitted which if recognized and guarded against should prove valuable in helping the amateur obtain good results.

A discussion of the uses and explanations of the construction of the stereoscopic, the metallurgical, and and the polarizing microscopes are also included. Valuable information on the use of the microtome was thoughtfully added along with specific instructions for sharpening microtome knives. Amateurs will undoubtedly appreciate the long check list of the difficulties commonly encountered in section cutting.

A comprehensive glossary is provided as well as a complete index of illustrations. The illustrations and diagrams are particularly appropriate and abundant. Technicians, graduate students in the sciences, and even full-fledged research workers will find this excellent, moderately priced guide very helpful.

BEYOND THE MICROSCOPE. *Being an account of a voyage of discovery in the borderland country between the "living" organism and the "non-living" chemical.*

By Kenneth M. Smith. Penguin Books, Harmondsworth, Middlesex, England; Penguin Books, Inc., New York. 25 cents. 7 x 4¼; 112; 1943 (paper).

Ever since the discovery of the first virus in 1892, biologists have been puzzled by this disease agent which refused to fit into any of the accustomed categories. Here was something which couldn't be seen and yet indubitably existed. Moreover, it was capable of producing infectious diseases in animals and plants which could be passed on indefinitely. The germ theory of Pasteur and Koch postulated that infectious diseases were caused by micro-organisms. Is the virus therefore a living organism of extremely minute size? After having read this little book you must decide for yourself what is the answer to this question, or if there is any answer to be given.

Here within the space of a little over 100 pages the author tells the story of those ultra-microscopic forms of living or non-living matter which scientists have chosen to call viruses, and incidentally, he does a splendid job of it. The discussion is not too technical or detailed and the average reader will find that he is able to follow the story with ease and ever-increasing pleasure and satisfaction. The author unfolds a fascinating story about: the viruses in history, the insect allies of the viruses (including the mosquito, louse, aphid, and leafhopper), of the viruses in everyday life, in farm and garden, in the tropics, studying the viruses in the laboratory (how to isolate, measure, grow, and see them), viruses and tumors, viruses in time of war and after, and how to combat these ultra-microscopic forms. He concludes with some interesting speculations on the possible origin, nature, and importance of viruses to modern-day man. There are illustrations showing some of the effects of the growth of several common plant viruses. There is no bibliography, but an index is available. To all those interested in learning more about the fascinating world "beyond

the microscope" this little volume is heartily recommended.

ON YOUR OWN. *How to Take Care of Yourself in Wild Country. A Manual for Field and Service Men.* *By Samuel A. Graham and Earl C. O'Roke. University of Minnesota Press, Minneapolis.* $2.00. 7⅝ x 5⅛; 150; 1943.

On Your Own is a field guide designed for the use of inexperienced men who, for one reason or another, may find themselves in the wilderness and in difficulty with their environment. It contains many suggestions which are valuable to both field and service men as a supplement to, but not a substitute for, a knowledge of personal hygiene and first aid.

In essence, *On Your Own* is a manual of practical ecology, designed for use either within the limits of Continental United States, or in foreign lands; in the tropics, or in the far north. It points out both the physical and biological hazards to be found in the field and tells how to meet them. Temperature extremes, minor injuries, quicksand, poisonous plants, insects, mammals, and parasites are some of the topics included. One section deals with food which can be taken into the field; another tells what can be obtained in the field and how to obtain it. In summary, a series of "do's" and "don'ts", which can be easily remembered is presented.

The book is interesting, yet non-technical enough to be understood by those who are not professional biologists. Much of it would be considered as "just common sense" by experienced field men. Nevertheless, it is often less painful to be told what constitutes "common sense" than to learn it through trial and error.

ROOTS OF BERGSON'S PHILOSOPHY. *By Ben-Ami Scharfstein. Columbia University Press, New York.* $1.75. 8½ x 5½; ix + 156; 1943.

In the closing chapter of this work Scharfstein poses the question "Was Bergson original?" and then decides that he was not. With the exception of a few obscure writers of the German school there was hardly a philosopher of any note from Plotinus to Evelyn Underhill whom Bergson had not read and from whom he did not borrow. This is no derogation of Bergson, but rather very much to the contrary. Most philosophical systems suffer from too much originality.

The reader who has not a pretty complete knowledge of the history and development of philosophic thought will have difficulty in getting much out of this book, for it fairly bristles with bibliographical references to unquoted luminaries of past ages. Even at that he will be likely to catch more of Bergson's drift from it than he would by attempting to read Bergson in the original without any preliminary preparation.

Perhaps the following paragraph, better than any other, embodies the central thought of Bergson's writings:

Bergson was asked if he was a mystic. He replied:

> If one understands by mysticism (as one almost always does today) a reaction against science, the doctrine I uphold is nothing from one end to another but a protest against mysticism, for it proposes to reestablish the bridge (broken since Kant) between metaphysics and science. This divorce between science and metaphysics is the great evil from which our philosophy suffers. . . . But now, if one understands by mysticism a certain appeal to internal and profound life, then all philosophy is mysticism!

MAN AND HIS PHYSICAL WORLD. *By Dwight E. Gray. D. Van Nostrand Company, New York.* $3.75. 9 x 6; xii + 665; 1942.

The author's purpose in preparing this volume has been that of providing a comprehensive, yet elementary course in the methods and materials of modern science for college students not majoring in one or the other of the specific branches of the field, and who will undoubtedly never receive any further formal training in pure science throughout their academic careers. For this reason, emphasis is placed on the scientific method, man's relation to natural phenomena, the basic principles of science, and on the interrelationships between the various fields of science, rather than on an intensive development of intricate experiments, techniques, processes and formulae.

Such standard subjects as astronomy, geology, chemistry, physics and mechanics are presented very simply, thoroughly, and logically in relation to the student's everyday surroundings and activities. Numerous timely topics, including petroleum, plastics and electronics, are discussed in the light of our present and future industrial economy. The materials of the text are adaptable to a wide variety of student levels, and teaching procedures, and present an excellent opportunity for developing the inductive method of thinking among students of moderate ability.

A list of test and check questions, as well as a group of selected readings relating to the various chapter topics are provided. There is a detailed index.

COMPANY MUSEUMS. *By Laurence Vail Coleman. American Association of Museums, Washington, D. C.* $2.50. 9 x 6; viii + 173; 1943.

The main purpose of this book is to show the nature and usefulness of company museums, and also to serve as a manual for people who have museums of this kind

to manage. This type of museum is wholly distinct from sale exhibits and advertising displays. It is an enduring establishment, not a momentary creation. The usefulness of such a museum, methods of exhibiting and collecting and other pertinent data are presented. An appendix lists the 80 companies in this country that have museums and the nature of their displays.

UNIVERSITY OF COLORADO STUDIES. *Series B. Studies in the Humanities. Volume 2, No. 1.* Containing the following papers: *Carlyle, Hitler, and Emerson: a Comparison of Political Theories*, by Irene P. McKeehan; *The London Stage*, 1870–1890, by E. J. West.

University of Colorado Press, Boulder. $1.00. 10 x 6¾; 84; 1943 (paper).

ERRATUM

In the March number of THE QUARTERLY REVIEW OF BIOLOGY (page 68), the price of the book "Memoir of Walter Reed," by Albert E. Truby, is incorrectly stated. The price is $3.50.